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"FOR BETTER SCIENCE TEACHING"

The Science Counselor

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A QUARTERLY JOURNAL *of teaching methods and scientific information especially for teachers of science in Catholic schools. Indexed in the Catholic Periodical Index. Published at Duquesne University, Pittsburgh, Pennsylvania, in March, June, September and December by*

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Science In The Elementary School

• By Florence E. Learzaf, M.Ed., *(University of Pittsburgh)*
PRINCIPAL, JOHN MORROW SCHOOL, 1611 DAVIS AVENUE, PITTSBURGH 12, PA.

Strong leadership in elementary science is an immediate need. Recent developments in the international scene have accentuated this need.

Unless teachers assume this leadership, it will be assumed by extremists.

The author takes a calm positive approach to the problem, and shows how science can be an integral part of the elementary program.

●

News reports during the last year concerning the development and launching of guided missiles, rockets, and satellites have caused the attention of the world to be focused on the important part that science plays in shaping our destiny. Daily we read of the critical shortage of scientists in our nation. Many plans are being considered to evaluate and replan our entire educational structure to meet this need. Some proposals suggest that the teaching of science on all levels, from kindergarten through the elementary school and on to the secondary school and university, must be emphasized more than it has been in the past. Most educators welcome this sudden interest of the general public and hope that science and the science teaching will regain some of their lost prestige and respect. However, emphasis on the teaching of science is not new in many fine school systems, for in these schools a strong, continuous program of science is an integral part of the curriculum.

The teaching of science must begin in the elementary school, since it is during these formulative and developmental years that the teacher sparks scientific interest and stimulates knowledge. At this level, it is important that the teacher identify, encourage, and teach children with scientific ability at an early age, for they will be our future scientists. It is also necessary to develop an appreciation and understanding of the impact of science in this technological age by all other boys and girls. These two groups constitute the challenge to the elementary science educator. The position held by these persons is a key one, for additional science education is built on the foundation which they begin.

Children of the elementary school age are extremely curious, enthusiastic, and interested in the world in which they live. The teaching of science, both natural and physical, is an important part of the curriculum which enables teachers to take advantage of these innate characteristics. The methods used by the teacher are all important, but first it is essential to consider the atmosphere in which some of these techniques can be used.

The atmosphere of the classroom provides the setting for science teaching. It is the proper climate within the science room that should allow even the most casual observer to know that "this is the science room." Every elementary classroom should contain some growing plants. This will include common house plants, along with those started by children from the seed of an avocado, a sweet potato placed in water, or carrot and beet tops placed in a saucer of sand. This setting will hold true for a self-contained classroom or highly departmentalized science room. In the self-contained classroom, a corner or table devoted to science should be in evidence. A bulletin board with clippings from newspapers and magazines for, "Science in the News" helps to make children aware that their school time is really a part of the current happenings in the world. Pictures well mounted and artistically arranged help make the room interesting. In addition, an aquarium and terrarium, along with specimens brought in by the children should have prominent spots. A box standing on end with an osage orange or a discarded snake's skin placed within, might otherwise go unnoticed if it were not for the caption, "Do You Know What This Is?"

With the atmosphere or proper climate provided in the classroom, the teacher will find it easy to encourage children to observe more carefully. This may be done by attracting attention to a specimen in the room. The sentences, "Watch this cocoon. The caterpillar is changing to a moth.", may be placed under the cocoon of a cecropia moth. A jar with several beans planted near the inside glass may have these questions placed beside it. "Watch the beans in this jar. Which will grow first, the roots or the stems?" Children should be encouraged to make observations outside of the school also. An assignment to look at the constellation of the big dipper and to draw the stars as they appear in the sky; or to ask children to look for alto-cumulus clouds and report to their classmates when they observe them, will remind children that science extends beyond the school room. The use of all of the senses to gather information and in arriving at tentative explanations should be encouraged.

Experimentation is part of the elementary science program. This does not necessarily mean a complicated setup with high school science equipment, but rather the use of simple material at hand, to try out or demonstrate with what children wish to know. Very young children who are placing a magnet on various materials to identify which materials are attracted to it are doing experiments on their level. In the upper elementary school, the wise teacher will be careful that "experiments" are not done as a form of entertainment or as a feat of magic. Here, the children should know and understand that a specific purpose is set forth. There are many occasions when it is worth while to "write-up" an experiment, but like written book reports, this phase should not be overdone. However, there

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Molybdenum—A Versatile Element

• By Benjamin H. Danziger
CLIMAX MOLYBDENUM COMPANY, A DIVISION OF AMERICAN METAL CLIMAX, INC.

Molybdenum, one of nature's most versatile elements, although well known metallurgically, is treated very briefly in most chemistry courses. Aside from its position in the periodic table and the molybdate tests for phosphorus, most chemists know little of its chemistry.

This article outlines the history, metallurgy, chemistry and uses of molybdenum.

It did not take man long to put gold and silver to work—these materials were considered precious back in earliest Biblical times. But a good many other metals which play an important role in today's civilization spent centuries sleeping in oblivion before their value was discovered. One of these is molybdenum.

Molybdenite, the major source of the versatile element molybdenum, was known to the early Greeks and Romans who used the words molybdos and molybdaena (respectively) to describe it. The first important step toward emancipating molybdenum came in 1778 when a Swedish chemist, Karl Wilhelm Scheele, discovered that by treating molybdenite with nitric acid, molybdic oxide resulted. Four years later, J. J. Hjelm isolated the metal itself.

Little more than a laboratory curiosity up until World War I, molybdenum rocketed into importance during this conflict. It was used primarily in new alloys for armor, other ballistic applications and the crankshafts of liberty engines. It also proved a good substitute for tungsten in high speed steels.

Demand for moly dropped considerably when the war ended, but availability of an assured supply at a reasonable price spurred new technological advances and the gradual adoption of moly-steels in various industrial applications. By the late 1930's moly was a well established material. World War II stimulated sharply increased demands, although at its close there was a slump in consumption during conversion from wartime to peacetime uses. Today, new applications continue to arise steadily—both metallurgical and chemical.

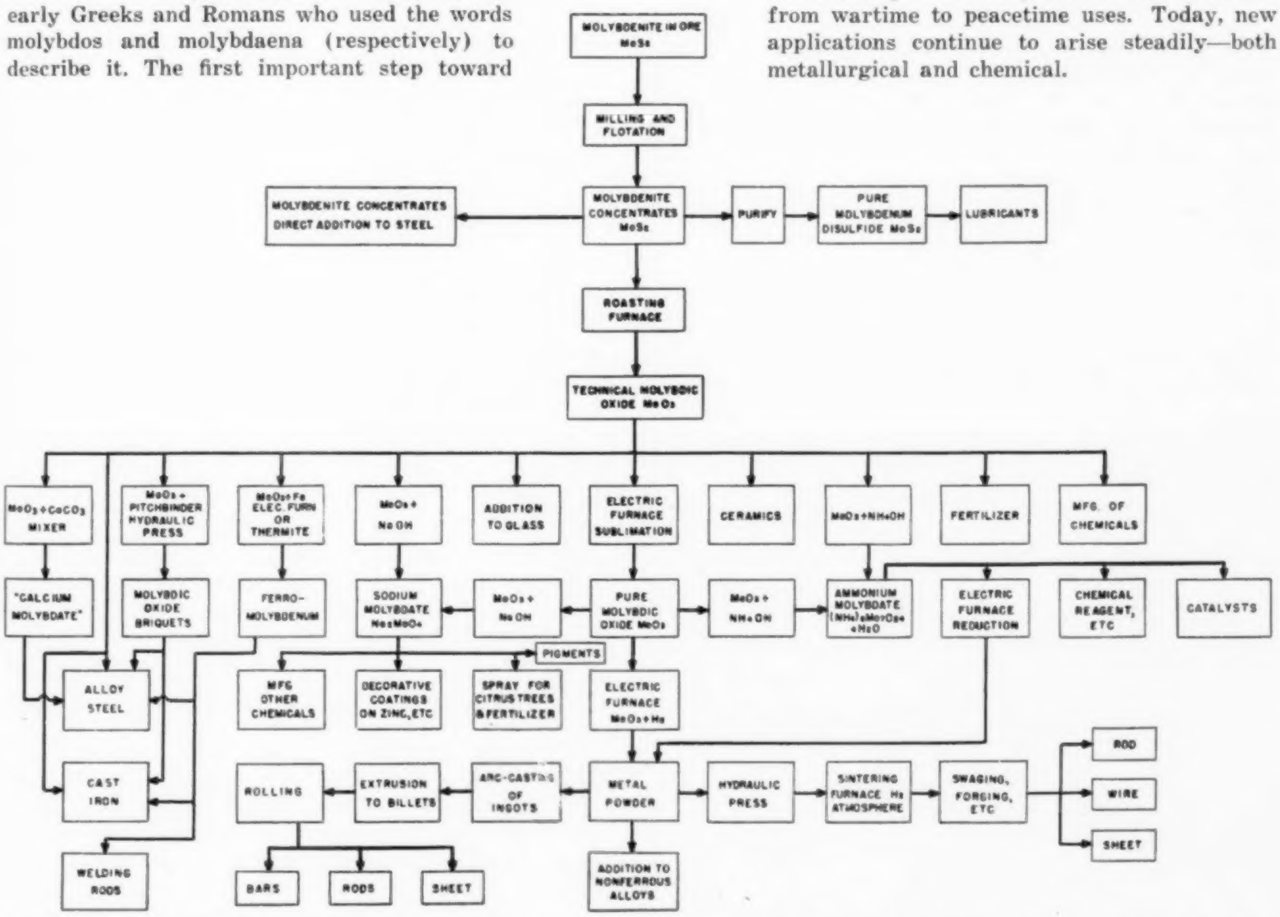

CHART taken from The Bureau of Mines Information Circular 7784, "MOLYBDENUM — A MATERIALS SURVEY," published by the U. S. Government Printing Office.

CONDUCTING A SMEAR test on the fifth wheel of a trailer truck to determine the extent of molybdenum disulfide remaining after the vehicle has undergone extensive service. Moly, with its strong affinity to metal surfaces, sustains lubrication long after the base lubricant containing it has been squeezed out or wiped away.

Forms of Moly Available

In performing its varied functions, moly is used in many different forms. One of the most commercially significant is molybdic oxide (MoO_3). It is produced in several grades—technical, purified, and briquets. Ferromolybdenum and molybdenum metal also are important commercial forms. Still others include: ammonium molybdate, molybdenum silicide, and sodium molybdate.

Molybdenum In Metallurgy

Steel

Molybdenum's principal role is as an alloying element—and in this field steel accounts for the lion's share of consumption. It is estimated that well over half of the alloy steels produced in the United States today contain moly.

One of moly's most significant roles in steel is its effect on *hardenability*. This property might be defined as the characteristic which makes it possible to harden by rapid cooling from above the critical temperature range. The net result of small additions of moly is a steel of relatively uniform hardness and strength, even throughout heavy sections.

Toughness is another highly important contribution of moly to steel. Simply defined, this property is the ability to resist breakage (as opposed to brittleness). Still other contributions are improvements in: resistance to softening on tempering; strength and creep resistance at elevated temperatures; machinability; and corrosion resistance.

Moly is used for many different types of steels which find application in a variety of industries. The major markets for moly steels are: automobile; petroleum-production; toolmaking; process industries; machine tool and heavy machinery; power and electrical; aircraft; ordnance; mining and earth moving; agricultural equipment; railroads and shipbuilding.

In the production of steel, molybdenum is used principally in two forms—molybdic oxide and ferromolybdenum. The form selected depends on the particular steelmaking process involved, the economics, and the type of steel being made.

Cast Iron

Increasing quantities of molybdenum have been used for the production of cast iron in the U. S. in recent years. The automobile industry, one of the largest consumers of moly iron, is using it to cast more and more parts each year—dies, cylinder blocks, cylinder heads, bushings, valve lifters, brakedrums, etc. Moly also plays an important part in the manufacture of quality iron castings for such applications as gears, valves and machine parts.

As an alloying element for cast iron, moly provides increased tensile strength. But in addition it makes possible a uniform response to heat treatment, greater wear resistance, improved elevated temperature properties, and uniformity in different castings made with the same iron.

In producing cast iron, moly is generally used in the form of ferromolybdenum.

Non-Ferrous Alloys

The versatility of molybdenum is demonstrated by its role in non-ferrous alloys. Varying according to the particular base with which it is combined, moly contributes any one or a combination of the following properties: corrosion resistance; hardness; resistivity; and strength at elevated temperatures.

The more important commercially produced moly-containing alloys are cobalt base or nickel base. High permeability nickel-iron alloys, for example, utilize moly for the purpose of decreasing sensitivity to cooling rate and increasing resistivity. In certain corrosion and heat resistant alloys, on the other hand, moly's purpose is to promote hardness and elevated temperature strength as well as to improve its corrosion resistance.

Molybdenum Metal and Molybdenum-Base Alloys

Under the stimulus of jet engine production during the past few years, alloys have been developed to perform at high temperatures. Moly's high melting point and good high-temperature creep properties make it particularly attractive for the development of heat-resistant and structural alloys which will bear heavy loads at high temperatures. Molybdenum base alloys superior to other alloys at temperatures above 1600° F are now used commercially.

TABLE I

Physical Properties of Molybdenum Metal

Atomic number	42
Atomic weight	95.95
Crystal structure	body centered cubic
Melting point	4730 F
Density—68 F	0.369 lb/cu. in.
Electrical conductivity—32 F	34% IACS
Specific heat—70 F	0.061 Btu/lb/°F
Modulus of elasticity (dynamic)	
80 F	45.5 x 10^6 psi
1500 F	40.
2500 F	35.
Modulus of rigidity	
80 F	17.4 x 10^6 psi
1600 F	15.
Poisson's ratio	
80 F	0.324
1600 F	0.321
Thermal conductivity	
70 F	68.2 Btu/hr/ft²/ft/°F
1650 F	62.4
Mean coefficient of linear thermal expansion	
68 to 212 F	3.06 x 10^{-6} per °F
68 to 1832 F	3.41

Molybdenum metal and molybdenum-base alloys exhibit some extremely interesting properties such as corrosion resistance, high temperature strength, and a very high modulus of elasticity. These properties combine to make this metal adaptable for such critical applications as jet engine buckets and guide vanes, dies, valves and valve parts, electrodes in glass melting furnaces, boring bars for machine tools and electric furnace parts.

Titanium has proved an effective alloying element for moly metal, promoting increased high-temperature strength. Other materials such as vanadium, tungsten and chromium also have been used for this purpose. The over-all strength of moly-base alloys is unusually good, when protected from oxidation, even at temperatures greater than 1600° F.

Molybdenum Chemicals

The chemistry of molybdenum is unusual—so unusual that it was described by the late Edgar Fahs Smith as "ambidextrous, bisexual and polygamous." It has valences in stable compounds of 0, 2, 3, 4, 5 and 6. It forms many simple cations and anions. Its complex anions make up an enormous family of heteropoly acids of high molecular weight. And its oxides and salts combine with organic hydroxyl and carbonyl compounds. Such a combination of properties makes for great versatility. It is this versatility which has helped establish moly as one of the principal heavy metals used as a raw material in the chemical industry.

If man was slow to realize the value of molybdenum in metallurgical applications, he was doubly so in discovering the usefulness of its chemical compounds. Although there were some chemical applications before 1940, it wasn't until around this time that applications for moly chemicals began to take on significance. The principal moly compounds used in the chemical process industries are: molybdenum disulfide, molybdic oxide, sodium molybdate (anhydrous crystals), and ammonium molybdate.

Molybdenum Disulfide Lubricants and Fillers

New designs and increased service requirements in the automotive field and in industrial equipment has intensified the need for lubricants which perform effectively under critical operating conditions. For this reason, molybdenum disulfide, which has unusual protective properties under extreme conditions, is finding growing use as an additive to greases and oils (it also is used as a dry film or solid lubricant). MoS_2 sustains lubrication thanks to its unique combination of physical properties: it films out on surfaces; it provides a strong, durable film; it maintains a low coefficient of friction; it remains thermally stable; and it resists chemical attack.

A great many maintenance problems—unresolved for years — have been suddenly overcome due to MoS_2 lubricants. Oils and greases containing this additive have proved effective under such severe operating conditions as: extreme pressures; extreme temperatures; corrosive environments; inaccessibility for relubrication; and motions of reciprocation, oscillation, and sliding.

DEEP IN THE HEART of the Climax Molybdenum Company mine at Climax, Colorado, where moly ore is secured. Situated at a height of 11,320 feet, this is the largest underground mine in the world, supplying the major portion of moly mined in the U. S. and the free world. It has an average daily production of well above 34,000 tons of moly ore—enough to fill some 927 freight cars or a train stretching 9 miles in length.

LOUIS PROMOS, sole producer of Ambrosia melons, compares a melon treated with molybdenum (*left*) with an untreated melon (*right*) on his farm in Leesburg, Virginia. Mr. Promos attributes an improvement in melon quality, size, color, and taste, in addition to a boost in yield, to treating his vines with sodium molybdate. Moreover, moly treatment increases the number of runners per vine from 3 to 7 and speeds up growth, he claims.

Mr. Promos treated his melon crop by spraying a water solution of sodium molybdate—1 ounce to the gallon—around the hills and vines. With an application of about 6 ounces of the molybdenum chemical per acre, a definite response was noted within 48 hours.

Molybdenum disulfide is a chemical having a molecular weight of 160.08, a melting point of above 2700°F, specific gravity of 4.8 to 5.0, and a hardness of 1 (Mohs Scale). It has a high affinity for most metals.

Once a film of molybdenum disulfide is established, it will provide effective lubricating action at temperatures between −100°F and +750°F in air. In a vacuum or inert atmosphere it does not show any change in structure or composition, even after heating above 2000°F. A chemically stable compound, it is unaffected by water, oil, alkalies, and most acids (except aqua regia and hot concentrated sulfuric and nitric acids).

MoS_2 is used as a filler for non-metallic solid materials in addition to serving as a lubricant additive. Its lubricating properties plus its unique ability to improve combinations of various mechanical properties make it valuable for this purpose. It is blended with finely divided nylon powder and extruded into molding pellets for use in making suspension bushings for trucks, rotors for airplane fuel pumps, and other such parts. Molybdenum disulfide also is used as a filler for phenolic laminates, other plastics, rubber, and asbestos.

Molybdenum in Agriculture

Molybdenum has been proved to be an essential element in plant nutrition. Trials in recent years have shown that where soil is low in moly content, addition of small quantities of sodium molybdate, molybdic oxide or ammonium molybdate can have dramatic results. Moly's primary function is to allow bacteria living in the nodules of plant roots to perform their normal function—that of fixing atmospheric nitrogen.

The first significant success story regarding the use of moly treatments came from Australia. Before the discovery that moly could be added to the soil, it was virtually impossible to produce healthy legumes on some of the slopes of that country. Now, addition of a combination of moly and lime makes possible luxuriant pastures where barren waste land once existed. Lands formerly supporting ¼ sheep per acre are now sufficient for 4 sheep per acre. The U. S., too, has witnessed surprising results. In 1956, for example, pea growers in eastern Washington and western Idaho treated over 5000 acres with sodium molybdate and obtained average yield increase of 50% and a net increase in gross income of $35 per acre.

Moly Catalysts

Moly chemicals are used widely today as catalysts in numerous manufacturing processes. The petroleum industry represents the largest consumer of moly catalysts. The race for higher and higher octane and low sulfur content ratings since World War II has led to development of new catalytic refining processes where moly is one of the preferred catalytic materials. Its chief advantage lies in the fact that it is resistant to sulfur and other poisons. And the relatively low cost of moly catalysts makes possible the use of efficient fluid-bed and moving-bed systems in several of the octane improvement systems.

Molybdenum is used in some of the preferred catalysts for the hydrogenation of coal and shale oils to liquid fuels. The chemical industry presents the greatest variety of catalytic processes based on moly, although it accounts for a relatively small portion of the moly catalyst market. The chief use is in oxidation processes (conversion of methanol to formaldehyde, benzene to maleic anhydride, toluene to benzaldehyde, etc.).

Molybdenum In Color

One of the first chemical uses for molybdenum was in pigments, namely in molybdate chrome orange. This represents the only major colored inorganic pigment developed thus far in the 20th century. Chemically it consists of lead chromate made to precipitate in an abnormal crystal structure by the incorporation of lead molybdate.

Molybdate chrome orange has a brilliant, deep reddish-orange hue, great hiding power, and high tinting

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The Small Computer And Decentralized Computing Facilities

• By C. F. Flannell, B.S.Ed., *(Southern Illinois University)*
ROYAL McBEE CORPORATION, PORT CHESTER, NEW YORK

Giant electronic brains have made possible the rapid solution of many complex problems in science, engineering and industry. However, the very excellence of their performance creates many difficulties.

The small computer can be used to overcome many of the difficulties encountered in the use of the giant computer.

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Digital computers of contemporary vintage have made two major contributions in scientific and engineering applications which were hardly possible for computers of pre-electronic vintage. First, they have solved many problems too large for even a lifetime of horse and buggy methods of calculation. Second, by assuming the burden of repetitious computations, they have provided engineers with more time for creative thought.

So valuable are these contributions to industrial technology that they have stimulated a remarkable development in the size and speed of computers. The giant brains are providing engineers with answers of precise accuracy in cases where educated guesses were the rule. The wide margin of safety provided with the educated guess resulted in the design of inefficient equipment creating continuously high costs of operation. In other cases cut and try methods involving the building and testing of prototypes of trial design were used. Now the testing of many trial designs can be simulated at electronic speeds to eliminate the expense of building and testing actual prototypes. Recognizing the importance of such developments, the engineer is quickly accepting the giant brains available to him.

However, the use of giant brains is not without its price. While computers have grown to be very large and very fast, they have also grown to be very expensive and very complex. The expense requires critical scheduling for efficient use and the complexity makes scheduling difficult. In addition, efficient computer operation requires highly trained personnel who are difficult to find. Furthermore, the large computing installation is not flexible enough to keep up with the fast-changing demands of the engineering group. Hence, after the engineer learns to rely upon the giant brain and uses is regularly, it becomes the source of several major obstacles.

The first obstacle an engineer faces in getting a problem solved on a giant computer is having the problem programmed; that is, put into machine language. I had personal contact with this problem during my employment in a large computing installation of an aircraft company. The last problem which I programmed had waited in line to be programmed for over six months. The engineers finally had to make a decision on the metal to be used in an air frame before they received the results of our heat calculations. Our calculations showed that the temperatures involved would stay slightly below the melting point of the metal selected by the engineers. If they had guessed wrong, thousands of dollars and a great deal of time would have been lost. This was a very important problem and the engineers were very unhappy with this computing service. Many groups waited even longer for their answers.

The second obstacle an engineer encounters in having a problem solved on a giant computer is the dual problem of communication and scheduling after the programming is completed. The data must be sent to the central installation each time a run is made. The large companies which have the large computers frequently are widely dispersed so that inter-office mail may require a half day for delivery. After the data arrives, it must be logged in, assigned a priority, punched in cards or tape for entry into the computer, and wait until the machine becomes available. Only then are the answers returned to the engineer.

In some situations, the obstacle to communication created by the large computer installation is even more critical. For many engineering groups, one day or even one week's service from the computing group is quite adequate; nevertheless, many engineers want their answers within a few minutes. One good example of this demand for quick results is in aerodynamic wind tunnel applications. In many cases when a wind tunnel test is completed, the engineers want to see the results of that test before they set up the next test; this requires that the pressures, temperatures, and other measurements which were taken during the test be reduced to physical quantities which are meaningful to the engineer. Such a situation provides an ideal application for a computer. However, if the engineer must wait a day for these results, not only is his work less effective but also expensive wind tunnel equipment is inefficiently used. Therefore such a delay represents a considerable financial loss to the company.

There are many other cases where immediate results are desirable. For instance, in research problems the engineer may first try a given set of values and then when he sees the results he may want to change one number slightly to observe the effect on the answers. If he must wait a day or two for his answers, he is less inclined to try a new value. When he gets an answer which is close enough, he is inclined to draw his conclusions without trying for a more accurate

answer. Hence, it appears that the barrier to communication with giant brains stultifies the experimental spirit.

In spite of this discouraging picture, a great deal of progress has been made toward improving the system of communication with the central computing installation. One method of improving communications is to feed data directly to the computer and receive answers immediately. Such a system in its ultimate form would be very complex indeed, and with current techniques is still impractical. The alternative method is to locate a computer at each source of data. The introduction of the small computer has made such decentralization possible. Hence many large organizations have become interested in a decentralized operation as a method of increasing the efficient use of their personnel and of breaking up the bottleneck created by giant brains.

Some electronic engineering companies have responded to this interest by developing very versatile small computers. Many of the building blocks for these computers were developed for use by military aircraft and ships where limitation of component size is important. The General Precision Equipment Corporation is using such building blocks in developing small electronic computers. The Royal McBee Corporation which has developed an international sales and service organization for its typewriters, office equipment, and business systems, is marketing these computers. These two organizations have combined their facilities to produce and market the Royal Precision line of data processing equipment. One of these products is the LGP-30 computer, a small electronic computer designed primarily for scientific applications.

What comparisons can be made of the small computer with the large computer? First of all, recent developments with magnetic drum and disc memory systems have made it possible to produce a large memory in small computers at a relatively modest cost. Furthermore, a small ratio of physical size to effective circuitry can be maintained by the use of time-sharing of components. As a result it has been possible to develop a truly general purpose computer of small size. Hence, the modern small computer can solve any problem which can be solved on the large computer; the only real difference lies in the time required for problem solution and the amount of human supervision required. Modern design techniques, then, have made it possible to put a very powerful computer in a very little space.

A second point in favor of the small computer is the ease of installation. Computers have been developed with remarkable capacity which occupy less space than a normal office desk, which operate from a standard wall outlet, and which require no more power than an ordinary home iron. For such computers no air conditioning is required and hence no major overhaul of buildings to house them as required for large computer installations. The cost of installation of such a computer is practically zero.

There are three principal ways in which small computers are being used today. One way is to use several small computers as satellites to a large computer in order to reduce the difficulties attending the use of the large computer. Another is to use a group of small computers to replace a large computer. A third way is to use the small computer by itself as the principal computing device for a company, division, or department. The expense of the large computer makes its use in this third case prohibitive. There are several interesting examples of such uses of small computers. Here is one.

The head of the computing department of a large aircraft company, after a six month feasibility study, recommended to management that they open the bottleneck of the central computing installation by purchasing a group of small computers to be located in various engineering departments. Their central computing installation operates on an "open shop" basis where the engineer does most of his own programming. This programming is simplified by an algebraic interpretive routine which translates algebraic expressions into computer language.

The programming procedure was to remain unchanged with the installation of the small computers. The engineers would continue to program their problems in algebraic form using the interpretive routine to translate this algebra into machine instructions. The engineer who had a small computer in his own department would use an interpretive routine which would produce a program for the small computer rather than the large computer. The engineer then would return to his small computer where his problems could be solved without the delay of sending the data to the central installation and waiting for it to be returned a day or perhaps a week later. With this system the engineer would make only one trip to the central installation or send information to the central installation only one time. Then he could continue to use his program independent of the central computing installation until he chose to solve another problem on the computer or make a major modification of the existing program.

The LGP-30 computer was recommended for this application because its order structure is compatible both with the large IBM computer and the Univac computer which this aircraft company is using. They planned to punch the program on IBM cards and use a card-to-tape converter or if the Univac computer was used, they would punch the program tape directly from the computer. The engineer would return to his department with a program tape ready for entry into the small computer.

The LGP-30 has been chosen to augment a large computer installation in another way. The compatibility of LGP-30 code with the codes of large computers has led to its use in program check-out. Anyone who has worked in a central computing installation realizes that an engineer rarely states his problem in the first writing exactly as he wants it; invariably he wishes

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Microwave Propagation Well Beyond The Horizon From Marconi to the Present*

• By Thomas J. Carroll, Ph.D., *(Yale University)*
STAFF MEMBER, LINCOLN LABORATORY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Recently, research on the propagation of radio waves shorter than a few meters has disclosed that their utility is not limited by the horizon. They can be usefully propagated over distances of several hundred miles when sufficiently high powers and large antennas are used, both for voice communications and for television. There continues to be much dispute about the mechanism of this kind of propagation well beyond the horizon caused by the troposphere, but it seems certain that a major new radio industry is developing from use of this so-called "scatter propagation."

It is arresting and fascinating to realize that Marconi himself performed the first experiments a quarter century ago, unappreciated until recently by radio experts generally.

The following talk was presented at the opening session of an International Colloquium on Wave Propagation at Paris, September 17, 1956, and was first published (in a French translation) in the May, 1957 issue of L'Onde Électrique.

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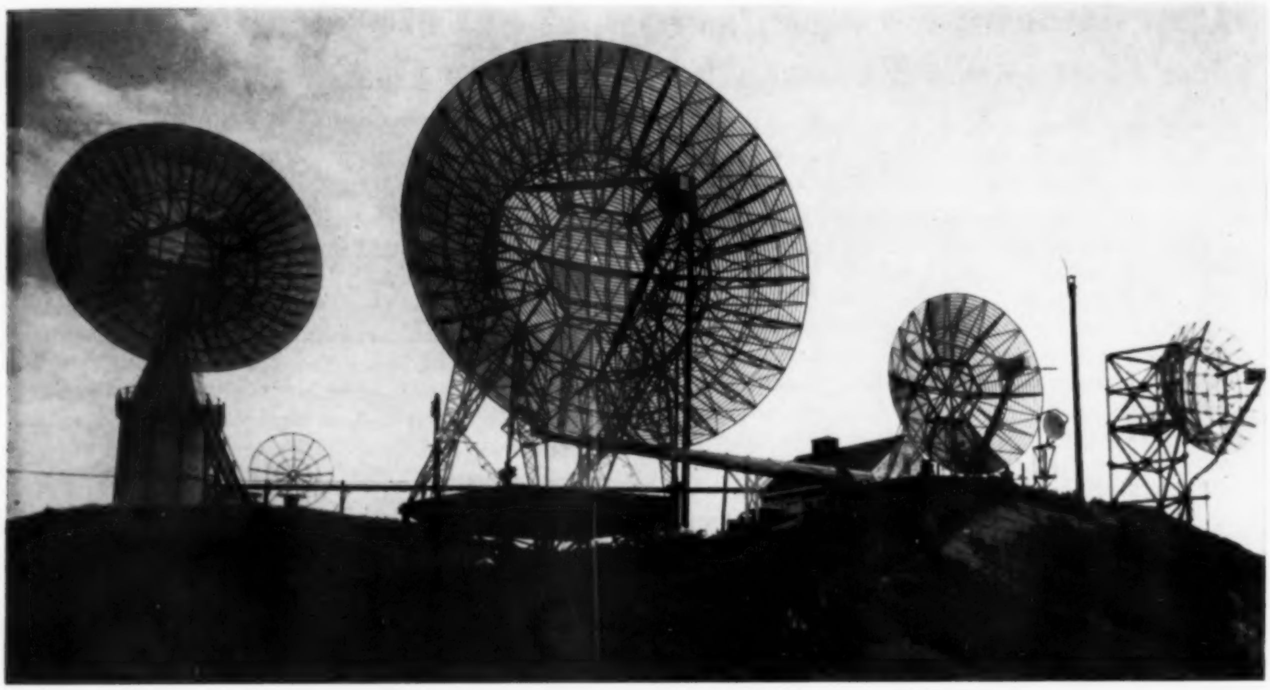
1. *Introduction: A Master's Prophecy*

I begin with two quotations from Marconi. The first comes from the introduction of a speech delivered on December 2, 1932, "Electromagnetic waves under one metre in length are usually referred to as Quasi-Optical waves, the general belief being that with them, communication is possible only when the two ends of the radio circuit are within visual range of one another; that consequently their usefulness is defined by that condition.

"Long experience has, however, taught me not always to believe in the limitations indicated by purely theoretical considerations or even by calculations. These—as we well know—are often based on insufficient knowledge of all the relevant factors. I believe, in spite of adverse forecasts, in trying new lines of research, however unpromising they may seem at first sight[1]." From the end of the same paper there is the remarkable prophecy: "In regard to the limited range of propagation of these microwaves, the last word has not been said. It has already been shown that they can travel round a portion of the earth's curvature, to distances greater than had been expected, and I cannot help but reminding you that at the very time when I first succeeded in proving that electric waves could be sent and received across the Atlantic Ocean in 1901, distinguished mathematicians were of the opinion that the distance of communications, by means of electric waves, would be limited to a distance of only about 165 miles." The next Marconi quotation has the date August 14, 1933, is from a speech entitled, "On the Propagation of Microwaves over Considerable Distances," and was made in describing his 500 Mc experiments with 25 watts of power in reflectors of two meters aperture, between the Italian mainland and his yacht Elettra during the sum-

MARCONI'S TRANSMITTER and Receiver installed in the Vatican (1932).

* The research in this document was supported jointly by the U. S. Army, U. S. Navy and U. S. Air Force under contract with the Massachusetts Institute of Technology.



". . . we have taken a long time to catch up with the prophecy . . ." Armstrong, ref. 3 in text. A photograph of antenna installations at the M. I. T., Lincoln Laboratory Round Hill Field Station near New Bedford, Massachusetts. The small 17-foot antenna used to receive voice transmissions from Armstrong's Alpine, New Jersey laboratory 167 miles away in 1953 is the second antenna from the left, to the right of the cylindrical tower on which a 60-foot antenna is mounted.

mer of 1933[2]. "In spite of the fact that the optical distance was only 30 kilometers, the radio telephonic and radio telegraphic signals sent by the transmitting station were received on the yacht with clarity, great strength, and regularity at a distance of 150 kilometers, that is at 5 times the optical distance." . . . "The theoretical explanation of the results obtained when the wavelength employed is taken into account presents, in my view, serious difficulties, even when using the calculations involving diffraction and refraction indicated by Pession in his paper, 'Considerations on the Propagation of Ultra-Short Waves and of Microwaves.'

"The speculations that may arise from such results concern the entire theory of radio transmission over distances greater than the optical one."

These sentences describing the 1933 experiments on 500 Mc were first read by me in an English translation from the Italian original in March, 1956. I have not yet met a contemporary propagation specialist who was aware of the prophetic little paper published in Italian by Marconi in 1933. My amazement at the clairvoyance in these words induced me to offer these historical remarks to the Colloquium. Even before the theoretical arguments over the explanation are settled, it is interesting to meditate on some of the events of the two decades of radio propagation history which elapsed before we realized the importance and significance of these early forgotten experiments. Surely the barest outline of the facts is arresting enough perhaps to induce historical ruminations in young researchers about radio history. Returning to the wavelength of Hertz's discovery, and of his own early demonstrations with copper bowl reflectors in England in 1897 on the Salisbury plain, Marconi when he returned to the communications possibilities of this part of the radio wave spectrum in 1931, had the additional stroke of genius to suspect and to verify his suspicions that the line-of-sight would not be the limitation generally believed to the distances over which these microwaves could be usefully propagated. Unfortunately enough, the line-of-sight shibboleth became gradually restored to expert and lay opinion for several decades more, before the truth of Marconi's vision began to dawn on us. In the 1953 words of fellow inventor, Armstrong, a lifelong admirer of Marconi, "When we remember the low power available for transmission and the crudeness of the equipment with which Marconi accomplished the 168-mile transmission, and consider the incomparably superior equipment that has been available to us from the technical developments of World War II, the wonder is that his prophecy went so long unheeded, and that the investigations of the past few years were so long deferred. Certain it is that with the tools at hand, we have taken a long time to catch up with the prophecy[3]."

I now plan to try to epitomize briefly the climate of opinion about propagation of microwaves beyond the horizon during three time periods, the nineteen thirties, nineteen forties, and nineteen fifties, and to follow with a few words, which seem even now fairly clear in

OPENING SESSION of International Colloquium on Wave Propagation, Paris, September 17, 1956. Left to right: Academician V. A. Fock (USSR); B. Decaux, President of the French National Committee of the International Scientific Radio Union; Prince Louis deBroglie, Nobel Prize winner for Physics (1929); R. Rigal, President of the Society of Radioelectricans; T. J. Carroll, M. I. T., Lincoln Laboratory; Prof. P. David, at lectern. Note earphones and transistorized pocket receivers for the simultaneous French-English translation system used.

the historical record, about the way radio history repeats itself, the interdependence of theory and experiment in discovering the laws of nature governing radio wave propagation, and the profoundly human side of this developing tale, particularly appropriate to the present time, and about which we should surely strive to learn more. It now appears that Marconi, who did not consider himself a physicist but who was awarded the Nobel prize for physics in 1909, who had already made two revolutionary discoveries about long and short wave propagation, was in 1932-1933 correctly suspecting beyond-the-horizon usefulness of microwaves, a prophecy which was fated to be disbelieved by professional physicists and engineers for two decades, despite the numerous researchers and enormous material resources devoted to the subject under the lash of a world war.

2. *The Nineteen Thirties: Pioneering Years, Without Curved Earth Theory, and Later With Excessive Reliance on it*

Judging from the published articles, the early experimenters on meter wave broadcasting and communications in the early nineteen thirties appeared to be not too surprised that high power sources allowed fields to be propagated well beyond the horizon, presumably because the numerical theory of how weak the diffracted fields should be on these frequencies was not available. Even for the decimeter waves of Marconi's experiments in 1932 and 1933, two experimenters in the United States published corroborating observations on propagation of UHF well beyond the horizon[4, 5]. Toward the end of the decade, the quantitative theory of diffraction for short waves and microwaves was worked out, with a predicted rapid exponential attenuation beyond the horizon of about 1 db/km at 500 Mc, and over 2 db/km at 5000 Mc. Plausible arguments were given for replacing the true earth radius by approximately 4/3 this value to allow for normal air refraction in the lower troposphere, before calculating the field diffracted around the earth bulge. For a few tens of kilometers beyond the 4/3 earth horizon, there seemed at least some of the time agreement between measured fields and fields calculated from diffraction theory about an airless 4/3 earth. The theoretical curves then came unfortunately to be believed at distances far beyond the horizon, where experimental checks had not been carried out, and where in retrospect we can see that the calculated fields are much too small to account for observations such as Marconi's carried out before the calculations were made[6, 7]. Curiously enough, meter wave measurements made continuously over more than a year in 1935 in New England by amateurs over distances of 5 times the line-of-sight distance are among the earliest indications of the incompleteness of the professional theoretical views[8]. It appears that the amateurs' lack of understanding of then current pessimistic views held by professionals about reliably overcoming the line-of-sight shibboleth without any help from the ionosphere saved them once again from believing something that was not so. "It is not so much what we don't know that gets us into trouble, it's what we know that isn't so." By the end of the decade of the 1930's, everyone seemed to believe in the calculated 4/3 earth curves; experimenters accepted the mathematical demonstrations without understanding the limitations, and mathematicians were unaware of the limited nature of the experimental checks, and the discrepancies with experiment well beyond the horizon.

3. *The Nineteen Forties: Discovery of Super-refraction and Unexpected Interference Fields*

During the period of the Second World War, the enormous development of radars, including those in the unexploited spectral region of centimeter waves, focussed attention at first on propagation within the horizon, since a radar echo involves a two-way propagation loss, and even the most powerful radars normally detect only targets above the horizon. The calculated values of diffracted fields beyond the 4/3 earth horizon came to be called "standard propagation" when texts were written for the increasing numbers of

users of radar and communication devices on meter and microwave wavelengths. Next the discovery was made in France of "anormal" propagation of 10 cm waves[9], in 1941, and independently in England of the phenomenon there called "anomalous propagation," to distinguish it from the "normal" or standard type[10].

Thus, almost the same term was used independently in France and England to describe the occasional propagation especially of centimeter waves to distances far beyond the normal horizon. Later the name more generally applied in England and the United States came to be "super-refraction" or "duct propagation." A very extensive effort both theoretical and experimental was undertaken in Allied countries to understand this striking radio analogue of optical mirage, caused by the occasional presence of almost horizontal layers in the atmosphere in which the rate of decrease of refractive index with height exceeds geometrical earth curvature, instead of being only 1/4 of earth curvature. The outstanding wartime success of the wave theory of super-refraction consisted of showing why the effect is much more striking and prevalent on centimeter than on meter wavelengths: a much greater duct-layer thickness is required for the effective trapping of energy of meter wavelengths than of centimeter wavelengths[11]. The effect of elevated super-refracting layers was intensively investigated, especially along the California coast, although calculated plane wave reflection coefficients of idealized elevated layers never successfully accounted for the observed fields well beyond the horizon as observed on centimeter and decimeter wavelengths[12]. Nevertheless, the idea persisted that propagation beyond the horizon should relapse back to the pessimistic 4/3 earth values when the atmospheric index variation with height was essentially standard, and free of super-refracting layers either at the surface or aloft.

Toward the end of the war, theorists in England had the idea that over certain seas, the humidity decrease with height might be rapid enough to cause a surface super-refracting duct to be present nearly all of the time, of sufficient thickness perhaps to trap semipermanently a centimeter wavelength[13]. This theoretically predicted effect was found, in 1945 experiments in the Carribean[14], and in 1946 in the Pacific[15]. A different and unpredicted effect noticed for 9 cm waves was that at distances beyond 80 nautical miles, the fields had a much lower attenuation rate than the current duct theory could account for, of the order 0.1 db/km, as well as rapid fading, and little dependence on antenna height. Similarly, attempts to calculate from wave theory of super-refraction observed non-optical fields beyond 100 miles as measured off the California coast also failed[16]. Finally extensive experiments over a 46-mile path in the Arizona desert investigated propagation in the natural diurnal cycle of surface ducts found there, but also showed up persistent and omnipresent disagreement with classical 4/3 earth diffraction theory especially for centimeter waves well below the horizon during the duct-free daytime atmospheric conditions[17].

Following the end of the Second World War, attention returned to propagation problems of frequency modulation and television broadcasting. After many FM and TV broadcasting stations came into operation, the complete inadequacy of the classical spherical earth diffraction theory for predicting interference fields well beyond the horizon became apparent from actual interference experience. This interference led to a three year stoppage in the construction of TV stations in the United States beginning in September 1948[18]. By the end of the decade, high power 400 Mc experiments in Iowa[19], and 3000 Mc North Sea observations[20] continued to increase the experimental evidence that something was seriously missing from our understanding of how radio waves propagate through the troposphere well beyond the horizon, on all VHF and microwave frequencies, at all times and places.

4. *The Nineteen Fifties: Discovery of Reliability, Communications Capacity and Several Explanations of Propagation Well Beyond the Horizon*

So far, a major achievement of our own decade has been the discovery of the omnipresence of reliable trans-horizon tropospheric fields, for communications of considerable bandwidth, on carrier frequencies in many thousands of megacycles of the microwave spectrum, which were regarded in earlier decades as fatally limited to low-power line-of-sight applications. The decade of the nineteen forties had recognized only the occasional anomalous propagation of microwaves beyond the horizon, but mistakenly presumed all tropospheric propagation well beyond the horizon to be similarly unreliable, and a cause only of interference fields[21]. Concurrently, during our decade the lively discussion of several proposed explanations of the omnipresent fields seems to have stimulated both experimental progress and rival theories[22, 23].

Synopsis of the period begins properly with 1949 when there was an attempt to relate the mysterious "angel" echoes from a visually clear atmosphere on microwave radars with the equally puzzling omnipresent tropospheric propagation well beyond the horizon[24]. The unexpected result, however, was the demonstration that most "angel" echoes in the Arizona desert were caused by insects and therefore unrelated to the scatter propagation phenomenon, as the fields well beyond the horizon began to be called. The hypothesis of incoherent scattering from turbulent fluctuations of the atmospheric index of refraction began to be systematically explored as a possible cause of the weak and fading fields now suspected to be omnipresent more than a few tens of kilometers beyond the horizon on all frequencies affected primarily by the troposphere[25]. Microwave refractometers made it possible to measure directly the tropospheric index of refraction in much finer detail than was formerly possible, especially the fluctuations caused by inhomogeneities of water vapor distribution[26]. For overland paths, deviations of the earth's surface from perfect sphericity were suspected by some to be a contributing cause[27].

The rise of several hypotheses for explanation of the effect seemed to stimulate more experimental effort. For stimulating experiments, even a theory or hypothesis which turns out wrong seems preferable to none at all. The first five kilowatt klystron transmitter on 1000 Mc proved able in the last half of 1951 to propagate fields reliably over 400 miles in Colorado, 300 miles beyond the horizon[28]. While the continual second-to-second fading of the fields well beyond the horizon made them look at first glance less useful than the steady fields at ranges within the line-of-sight, yet it had already been observed first in Arizona and then in New England[29] that the shapes of microsecond pulses over non-optical centimeter wave paths appears to be preserved, for the most part. High power VHF broadcasting[30] and point-to-point communications[31] well beyond the horizon seemed always to indicate no impairment of the modulation when the signals were sufficiently above noise level.

Once the fields well beyond the horizon from sources of high effective power were realized to be omnipresent, some investigators began to wonder whether the phenomenon should properly be considered to be only an unwanted interference effect. Perhaps, after all, the fields could be put to constructive uses, despite the long tradition of the line-of-sight shibboleth for microwaves[30a]. This possibility required that knowledge be gained about any possible degradation to the modulation by the still mysterious propagation mechanism. Systematic experimental efforts to discover any inherent bandwidth limitations of the propagation mechanism responsible for twilight region propagation were undertaken in 1953, with both wide band frequency modulation and pulse experiments. The results have been extremely encouraging, for up to the present time, using narrow beams, no serious degradation of modulation bandwidths at least up to the 4 Mc bandwidths required for transmission of television images have been observed on considerably non-optical tropospheric paths[32]. After these experiments, it appears certain that many thousands of megacycles of the microwave radio spectrum are capable of providing reliable non-optical communications paths to several hundred kilometers, provided only that the high power and large antenna requirements can be provided for the bandwidths required. Since mankind seems always capable of finding uses for radio waves for which there is no available spectrum space, there is understandable cause for elation that nature does after all permit the reliable use of the relatively broad microwave spectrum without relays over distances much larger than line-of-sight.

The large antennas (up to 60 feet aperture) and high power transmitters (up to 50 kw) which have created in the last three years many UHF and microwave communication links of length considerably in excess of the line-of-sight, afford more tangible evidence than mere words of the power of the right idea[33].

Finally, it has been suggested that the fields well beyond the horizon may be considered as guided waves in the normal air layer, idealized to be a tapered layer of air dielectric[34]. The effect is attributed to coherent molecular scattering as in optical dispersion theory and is thought closely analogous to optical twilight in clear air. The guided wave theory thus attributes a portion of twilight field to the idealized air stratification caused by gravity, to which fields caused by micrometeorological turbulence or super-refracting layer effects may at times be added. Whatever combination of mechanisms proves responsible, the omnipresent weak fields beyond the horizon seem related in their permanence more to ground wave propagation than to the fields propagated by the highly variable ionosphere.

5. *Several Lessons and a Plea for Early History*

Radio history seems to be repeating itself. Once again, the useful applications of tropospheric propagation well beyond the horizon are being made before scientists have come to agreement over what has been discovered, as has happened so often before in radio history. De Broglie spoke as follows in Paris ten years ago about the radio history of the first quarter of this century, when professionals regarded the long waves as the only important ones, and consigned the "useless" ones shorter than 200 meters to the amateurs, not without a certain disdain.

"The mishap suffered by the protagonists of long waves involves this lesson: it shows how necessary it is to guard against holding too completely to theoretical considerations in problems where one is not sure of having been able to take account of all the relevant data (and is one ever sure of knowing all the data of a problem?). If theory has frequently guided scientific researchers and resulted in admirable discoveries, if it is necessary for the progress of science, it has also at times been able to delay these advances when we have relied too blindly on certain of its conclusions which are always subject to revision[35]."

It was neglect of the ionosphere which led to the mishap suffered by the protagonists of long waves for the first quarter of the century, but this time it appears to be the neglect of the full effect of the air ocean in which we live which led to the neglect of the beyond-the-horizon capabilities of tropospheric propagation for nearly another quarter century.

Yet in a deeper sense, the point really being demonstrated by this developing bit of radio history is really the interdependence of theory and experiment in man's struggle to discover more of nature's laws. If the guided wave theory turns out to be the surviving explanation, then we can be grateful that it was the wartime pressures in the United States and England which caused several theoretical physicists normally interested in Schrödinger's wave equation to apply methods common to wave mechanics to the enrichment of solutions of the older Maxwell equations of radio wave propagation[36]. Throughout the radio history I have been trying to epitomize, there are clear instances where lack of theoretical understanding of the meaning of experimental measurements delayed their full utilization just as surely as the docile acceptance by experimenters of an incomplete theory of curved earth

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Science In The Kindergarten

• By Mrs. Marguerite Zehner, B.S., M.Ed., *(University of Pittsburgh)*
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Inquisitiveness is a natural trait in children. Even in the kindergarten, science can be used to challenge the child with interesting and meaningful experiences.

Mrs. Zehner outlines a simple project that can be used to associate the child's daily experience with the study of science.

A kindergarten or primary school project has served an all important and basic purpose if it has provided a bridge between a child's own real world of taste, smell, and feel and some simple book or other tool of education.

If that bridge has not been provided in kindergarten, some children drudge through several grades seeing in the rote of school only something unreal and unimportant which elders have forced upon them.

The first time a kindergartener sees a real bird at close range at a window bird feeder and then runs to look again at some bird picture he has seen, he has crossed an educational bridge. When he finds joy in comparing, in detail, things of his world with their reproductions in books around him he has become a student interested in research.

Everything the teacher does to bring the child's own world into the schoolroom and then explain about it with pictures, books, and projects in a playworld atmosphere helps to sell school to the pupil in a most natural way.

Nature provided the inquisitive child. Guiding that natural inquisitiveness into orderly research is a high accomplishment of teaching.

Unless, almost by subterfuge in some instances, a teacher plans the use of books and other tools of knowledge in association with childish inquisitiveness, there can be a period during which school is just an annoyance to even a bright child.

Once a child has found that something he sees or handles becomes vastly more interesting when, on his own, he reads about it or studies a picture, education has another convert.

It is possible for pupils actually to pass through one or more grades without using any part of what they have learned.

The extent to which some simple gadget of nature-lore, play, or handicraft can be usefully associated with reading, writing, and arithmetic is limited only by the skill, patience, and ingenuity of a teacher.

The purpose of this preamble has been to explain why it is practical to spend precious school time teaching such projects as the making of pine cone bird feeders and pomanders. These are but examples of scores of projects which are useful in helping pupils become interested in research, the natural pathway to knowledge.

If study material and pictures from many sources relating to projects used in elementary science are not provided before a project is started and as it progresses, the true purpose of this method of education is not being accomplished.

In my classes pupils begin the project of making pine cone bird feeders by planning the assembling of necessary materials. They also plan in advance for the selling of some of the feeders to buy feed to attract birds to our schoolroom windows. Simple problems of

Coming in for a Landing and Lunch — This black capped chicadee appeared out of nowhere with a lilting chirp of approval within two minutes after this seed studded suet pine cone was hung to a branch. His pal on the branch above awaits his turn at one of the favorite feed sources of many winter birds.

NIMBLE FINGERS PREPARE A BIRD FEAST — Gordon Miller does a fine job of loading a dried pine cone with coarsely ground suet. He knows that even when the weather goes far below zero winter birds can peck loose the very type of food which will keep them warm and healthy.

economics and arithmetic are involved and many pupils realize for the first time that arithmetic has a real personal use.

The pine cones around which the chopped suet is moulded become more than just inanimate objects. On another tangent the fundamental facts of tree life and reproduction are studied. This study material is provided first in oral narrative and then by bookshelf visits.

Pine cone bird feeders have been used many times as a project for several reasons. Pupils enjoy making them. No great skill is required. They have a practical value. Materials required are readily available.

A seed-studded, suet encased cone will attract more birds in wintertime than most any other type of feeder.

School study of ornithology is simplified by having the birds fly to the schoolroom windows rather than to have pupils walk to see the birds. Even in rather densely populated cities most birds which winter in temperate latitudes eventually will find properly placed bird feeders.

Our bird feeders are made from well dried pine cones from six to eight inches in length. Wholesale florists usually stock them for decorative purposes. Fresh suet is cheaply available at almost any shopping center meat market. It should be obtained after being coarsely chopped in the butcher's power grinder. Hand grinding is a tiresome and dangerous job. Each feeder requires about one pound of suet and several ounces of wild bird and sunflower seed.

An 18-inch length of soft iron or copper wire is used to suspend the completed feeder. This is entwined tightly to the apex of the cone before filling.

The filling operation is carried out on several layers of newspaper spread on each desktop. Each pupil is supplied with a wired cone and a pound of suet. Even the less interested pupils find something intriguing about pressing the plastic ground suet around the pine cone petals. After the interior of the cone is filled it is covered smoothly with the remaining suet and then is rolled in a mixture of sunflower and wild birdseed in a heavy paper bag. In this manner the surface of the cone is covered and some seed is embedded.

Most projects involve making a cone for each member of the class to take home. Several are provided for coaxing birds to the schoolroom windows for study and others are sold to aunts, uncles, and friends for one dollar each. Those sold at Christmastime are attractively packaged in cellophane freezer bags and tied with a red ribbon to which is attached small hemlock branches.

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A PRESENT FOR MOTHER—Carol Blotter patiently studs a large Delicious apple with cloves. When the apple is completely coverèd and it has been rolled in a mixture of cinnamon and orris root Carol's mother will have the perfect pleasant scent pomander for her favorite clothes closet.

The Inorganic Bioelements In Animal And Human Nutrition

With Some Recent Practical Experiences

• By J. F. Wischhusen
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The biological sciences for well over the past decade have been so preoccupied with developments that concern enzymes, hormones, antibiotics, viruses, and even stimulants and tranquilizers, not to mention the drugs and vaccines calculated to combat or destroy disease germs, that compounds and ions of the essential inorganic elements have been overshadowed, if not deliberately neglected, perhaps for financial reasons.

"DIET FRIGHTS" featured in the daily press center around the disputed roles in heart disease and vascular troubles of unsaturated versus saturated fats, and refined carbohydrates versus their natural prototypes. Food processors may therefore come in for publicity, if not scientific scrutiny on all forms of food refinements that have taken place at the expense of nutritional values. It may be well to point out that the main difference between unsaturated compared with saturated fats is the greater number of so-called oxygen bonds held by the former and extra hydrogen attached to the latter. Both oxygen and hydrogen are inorganic bioelements; so we are in effect dealing with a preponderance of the one over the other. The difference between refined carbohydrates and their natural prototypes is largely one of the removal of vitamins, hemicellulose, enzymes, etc., and a conversion into pure starches and sugars that become empty calories and are ideal foods for the parasites of the human or animal bodies that ingest them. Cooking and other forms of heat treatments destroy valuable enzymes and even some amino acids. Cooking of foods, pure starches and white sugars are by many regarded as marks of civilization, when in fact they are ideal media for the growth of parasites and pathogens.

Upheavals are possible such as the tobacco industry's concern about lung cancer. In respect to this, two observations come to mind. In the first place what is the reason for the existence in nature of the tobacco plant? To be used for smoking? Of all plants tobacco is a cultivated crop plant that is high in ash, in some sections amounting to as much as 27%, which makes it one of the best crops to be returned to the soil as green manure. Tobacco stems when used as fertilizer are known to suppress certain parasites, such as nematodes, that inhabit soils. And why do people smoke? Not for objects of health; leaving as purposes mere pleasurable indulgence or the use of a mild narcotic. In the second place there is hardly a thing in this world that has not at one time or another been suspected of causing cancer. According to Max Gerson, M. D. cancer is a problem of metabolism and there is no cancer in normal metabolism [1].

Metabolism means rearranging into healthy body cells the atoms that are contained in the nutrients ingested. Herein are also involved the catalysts that facilitate reactions without necessarily entering into them; and anti-metabolites that can inhibit beneficial as well as detrimental reactions. It is not possible to ingest only beneficial nutrients. Elimination of what the body does not require, or has used, is therefore as important as assimilation of what the body does require, or can use. But the process of metabolism, consisting of anabolism (build up process) and catabolism (breakdown process), starts with what enters the mouth, and is therefore under the control of the eater at eating time. In a like manner the feeder at feeding time controls what nutrients our domestic animals are to metabolise.

Health scares are to be expected when it is realized that 90 million Americans are said to be in substandard physical conditions. They themselves have it in their power to correct this by simply selecting from foods such nutrients as they may need for optimum health, longevity, and mental acuity. The sources of foods thus become immaterial. All food, as all matter, is composed of the elements, called atoms, of which 102 are now known. Since the animal and human bodies are part chemical and part physical, body structure involves the principles of biochemistry and biophysics, both exact sciences. They may be studied by anyone prepared to do so. THE SECRETS OF HEALTH ARE POSSESSED BY NONE OTHER THAN THOSE WHO ARE HEALTHY! There are said to be in this country some 3200 centenarians who enjoy exemplary longevity and health. Here are criteriae for study. In ancient Greece it was customary first to be a student of nature, and then a student of nature perverted by disease. Thus even today the difference between disease and health could be ascertained, and traced to their causes.

At least 37 elements have been in one way or another linked to the fabric of life, and been classified as bioelements[2, 3]. So the student of biology in relation to body health is concerned with at least that number in the table of elements[4]. A scrutiny will show that many of the essential elements fall into the class of heavy metals. They are closely related either according to atomic weight or other physical characteristics. For instance the elements #23 to 30, generally called trace elements, are successively apart from each other approximately only the weight of one or two hydrogen atoms, or even only a few electrons, viz:

	Element	Atomic Weight	Electrons
At. No. 23	vanadium	50.95	2,8,10,3.
24	chromium	52.01	2,8,11,3.
25	manganese	54.93	2,8,13,2.
26	iron	55.84	2,8,13,3.
27	cobalt	58.94	2,8,15,2.
28	nickel	58.69	2,8,16,2.
29	copper	63.57	2,8,17,2.
30	zinc	65.38	2,8,18,2.

The elements heavier than the above have not been particularly associated as yet with biology, except:

	Element	Atomic Weight	Electrons
At. No. 38	strontium	87.63	2,8,18, 8,2.
42	molybdenum	96.00	2,8,18,10,4.
53	iodine	126.932	2,8,18,18,7.

Now whether we adopt the atomic science principle of progressive changes from a light to a heavier atom through the acquisition of electronic energy, or whether we go by forces of gravity and centrifugation, these elements are neighbors, so that where one is found others may be expected to be present; where one perform others also perform vital functions. Iodine for instance would not be a bioelement if not all the 52 preceding elements had contributed to the construction of the higher forms of animal and human lives which cannot exist in the total absence of iodine.

There are reasons to believe that all biological reactions will be explained some day by the atomic science principle. Fertilizers may be designed to meet the specific needs of crops in comparison with the particular composition of the soils on which they are to be grown. The presence in our soils of all essential elements and the nutrient-holding capacity of the soils determine plant growth and quality. But some essential plant nutrients are also obtained from the atmosphere and absorbed through foliage. Plant roots do not select from soils the elements needed by animals and man for transmission through feeds and foods. They construct their own proteins, fats, vitamins, sugars, fibers, etc., always with the aid of water, air, sunshine, darkness, and temperature changes. The last three are essential for photo- and starch synthesis. The concept is largely prevalent that when essential elements are not in the soil, neither plants nor animals can secure them should be re-examined along the principle that each form of life is a biologic entity, and only concerned with its own growth and propogation, not those of their predators. At best only a certain edible portion of a plant is used as food and feed, whereas the total plant economy embraces roots, stem, herbage, seeds, etc., and there are hardly any plants consumed whole, or as grown in nature. There are more inedible and toxic plants than edible ones. Total rations for farm animals may be formulated for the various production goals, and optimum quality objectives will reflect true economics, over the life cycle of several generations. All foods may be assembled to meet the needs of man for health, longevity and mental acumen. A good slogan to adopt would be:

all essential elements in every American acre
all essential nutrients in all our feeds and foods
from sources that are immaterial.

The consequences of malnutrition manifest themselves very often only in later life or in the following generation. An adequate diet before and during pregnancy is of the utmost importance. Premature births, babies too weak to live, or with deformities are all the result of inadequate maternal diets in which proteins and minerals play dominant roles, but all food groups are involved. Young women should be taught to eat well rounded diets—one that contains adequate amounts of high quality proteins such as meat and dairy products, and of fruits and vegetables, as much in their raw but properly ripened state as possible, whole grain breads and cereals, and unprocessed fats not overheated, to supply the needed energy for the time to bear children. These foods can be obtained economically, in fact in terms of nutrient values they cost less than modern refined baked goods, processed starchy foods, soft drinks, sugars, and candies.

The nutritional approach to both health and disease will no doubt gain acceptance to the extent that people become conscious that they are what they eat or their ancestors have eaten, and what the more or less ever-changing total environment factors are. Enough of the right kind of food may prevent juvenile delinquency, as well as industrial accidents, and absenteeism. The laws of chemistry and physics worked 4000 years ago the same as now and will in the centuries to come, so it behooves us to understand them and apply them for our benefit. Pertinent articles on this subject have appeared in the Science Counselor from time to time, and a number of them are listed under references to the literature[2, 4, 5, 6, 7, 8].

Some recent practical experience concerns the research work of John D. Haseman, Ph.D. who has devoted a lifetime of study to the catalytic actions of activated carbon and silicon that produce large colloidal changes due to their energizing of hydrogen and hydroxyl-ions made from water by their energies of activation. The activating agent can be either hydrochloric acid or photo-chemical energies of 3000 to 4200 A° of ultraviolet light[9]. He states that activated carbons and silicons under proper vital conditions can put in or take out hydrogen-ions, hydroxyl-ions, or oxygen-ions as often as 160 times without reactivation or re-energisation. This ability of the three factors carbon, silicon, hydrochloric acid plus a host of other regulatory materials which of course include all essential "minerals", vitamins, and hormones, etc., may modify the operation of Mendel's law of genetics, and the existing theory of the genes; because the gene shiftings, gene cross-overs and gene interchanges do not cause the changes in the differentiation of characters as is now claimed, but changes in the wave lengths, etc., of the energies of activation can cause these character changes. The human body for instance may be considered a colloidal sack, essentially composed of water, hydrogen- and hydroxyl-ions that penetrate every portion of the sack. The tremendous potential energies that can be exerted by the human and animal bodies must have a source that is only indirectly related to food metabolism. Hence there is a basis for the Haseman contention that special amorphous carbons and silicons activated with hydro-

chloric acid or light intensities of 3000 to 4200 A° assume special importance as keystones of animal and human life. The activated silica normally plays a role in plant growth, in making fats, starches and proteins for the animal kingdom.

In medical practice activated carbon and silicon materials have proved of value in regulating stomach activities, the central seat of food metabolism, and in preventing irritations of the gastro intestinal tract, such as: esophagitis, gastritis, duodenitis, spastic colitis, mucous colitis and food allergy[10]. Interest in hydrochloric acid is revived by the re-publication of the book "Three Years HCl Therapy[11]. All cancer cases are known to be deficient, among other things, in hydrochloric acid. Bursitis, osteoarthritis, cysts, kidney- and gall-stones when due to excesses of calcium or other alkali-compounds, fibroids and blood carbonates are reported to have been successfully treated with HCl injections or oral administrations of glutamic acid hydrochloride. Livestock, too, of course, benefits by a feed supplement of hydrochloric acid in the case of a deficiency of this essential body acid, or in the case of excesses of calcium and other alkalies.

Then there are various experiences with inorganic cobalt compounds. Cobalt received no recognition as an essential element until it was shown that Vitamin B_{12} is a cobalt complex. It might just as well be classed a phosphorus complex because there is one atom each of Co and P present in the B_{12} molecule. The other elements vary, but the formula generally accepted for Vitamin B_{12} is $C_{63}H_{90}O_{14}N_{14}PCo$. It can be seen that in the synthesis of Vitamin B_{12}, the two inorganic bioelements Co and P remove appreciable amounts of carbon, hydrogen and nitrogen from the system, something B_{12} can no longer do. To the extent of B_{12} the elements cobalt and phosphorus prevent the formation of Cyanogen (CN), prussic acid (HCN) or even ammonia (NH_3) all of which are highly toxic. The fact that B_{12} is recoverable from manure and human feces makes this vitamin an end product, to be eliminated from rather than administered to the animal and human bodies. Multiple sclerosis cases suffer from injury to the nerve sheath, myelin, which some authorities have related to their inability to remove cyanide from their system[12], and this explains why many MS cases in Cleveland benefit from a cobalt therapy, but not from one of Vitamin B_{12}.

That a high blood level of magnesium may be related to comparative immunity to coronary artery disease by the Bantus is reported from the South African Institute for Medical Research. Their studies also suggest that a magnesium compound is a valuable therapeutic agent in reducing high serum cholesterol. Bantus appear to have more magnesium and less cholesterol in their blood than Europeans or Americans[13]. The possible role of this element in cholesterol metabolism and atherosclerosis has not been fully appreciated. A paper on the importance of magnesium in human nutrition appeared in the pages of this journal in December 1954[6]. A magnesium deficiency in cattle has long been known, but in practice this element is thought to be plentiful in modern rations. All green plants contain chlorophyll which is a magnesium molecule. It took some severe cases of mastitis in dairy cows in New York State to prove the value of extra magnesium supplements to the rations for dairy cattle. Such cases appear to have originated from molds or yeasts in spoiled corn, or ensilage, and there is one report that a heavy application of ammonium nitrate to hay lands following the first cutting resulted in severe mastitis to an entire dairy herd that was pastured thereon. Such a condition would no doubt have been correctible with magnesium and other alkalies to offset the high nitrate ions and their hyperacidity. The futility of treating such cases of mastitis with sulfa drugs and antibiotics is obvious; yet that is the customary medical treatment. Other cases of so-called hypomagnesemia are reported from Northern Ireland and they were readily correctible and preventable by a supplement of 2 ounces magnesium oxide per head per day to the rations of cattle involved. Formerly this trouble occurred mainly on early spring pastures and was known as "grass tetany", "lactation tetany" or "staggers," evidently related to an excess of potassium in young pasture grasses that led to a deficiency of magnesium. Now it seems that high nitrate fertilization can also induce a magnesium deficiency in grasses that is then carried over into the hay or ensilage so that it occurs at all seasons of the year. Another gratifying report from New York concerns the top production and improved health of a large number of dairy cows fed supplements of iodine, other multiple trace elements as inorganic compounds, and mono calcium phosphate. Over an eight months period of feeding these inorganic supplements in prophylactic doses milk production amounted to 10,000 to 12,000 lbs., there were no breeding troubles, no milk fever, no acetonemia, no cows off feed, no caked udders nor retained placentas. There was neither brucellosis (Bangs Disease) nor mastitis as might be expected, because the trace elements and iodine used were of the ratios and numbers as determined deficient in brucellosis cases and reported in this journal in September 1950[5].

The newer knowledge of nutrition in regard to "mineral" metabolism both for humans and livestock stresses certain ions in proper proportions. It would appear that calcium and sodium ions are generally excessively present in feeds and food and to this can now be added the nitrate ions. Sales propaganda for the greater use of salt and other sodium compounds, lime, and nitrate fertilizers may have something to do with this. But under natural conditions there would seem to be a relation to a deficiency of lime and the incidence of tuberculosis. The soil map of the USA showing absence of calcareous soils corresponds with the areas in which tuberculosis is present. It is known that the tubercle baccillus can not grow in a medium high in calcium.

Dr. William A. Albrecht, Soil Scientist, University of Missouri, as early as 1943[14] published the following chemical analysis of the Human Body in comparison with that of plants and soils, viz:

(Continued on Page 32)

Understanding The Physical World Through Measurement

The National Bureau of Standards has released a new color motion picture designed to interest young people in the world of science. This film, "Understanding the Physical World Through Measurement," dramatizes the role that measurement has played in man's efforts to harness the sources of energy.

The story is presented in the form of a lecture-demonstration, essentially that enthusiastically received by some 6,000 high school science and mathematics students who attended the Bureau's Guest Week Program in May 1957.

The film traces the historical development of means for utilizing energy sources, from the muscles of prehistoric man, to the steam engine, and, topically, to uranium fission and free radicals. The significance of physical measurement to this dramatic advance is illustrated by experiments duplicating those important scientific discoveries that have revealed new sources of energy to mankind.

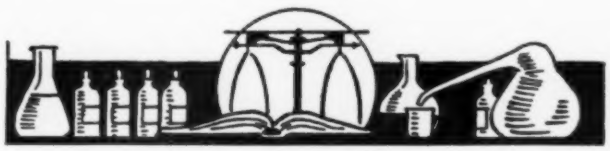
Included are demonstrations illustrating the transformation of energy—mechanical, chemical, thermal, electrical, and nuclear—from one form into another. For example, the Bureau's radiation balance is used to measure the heat energy generated by radium in its disintegration.

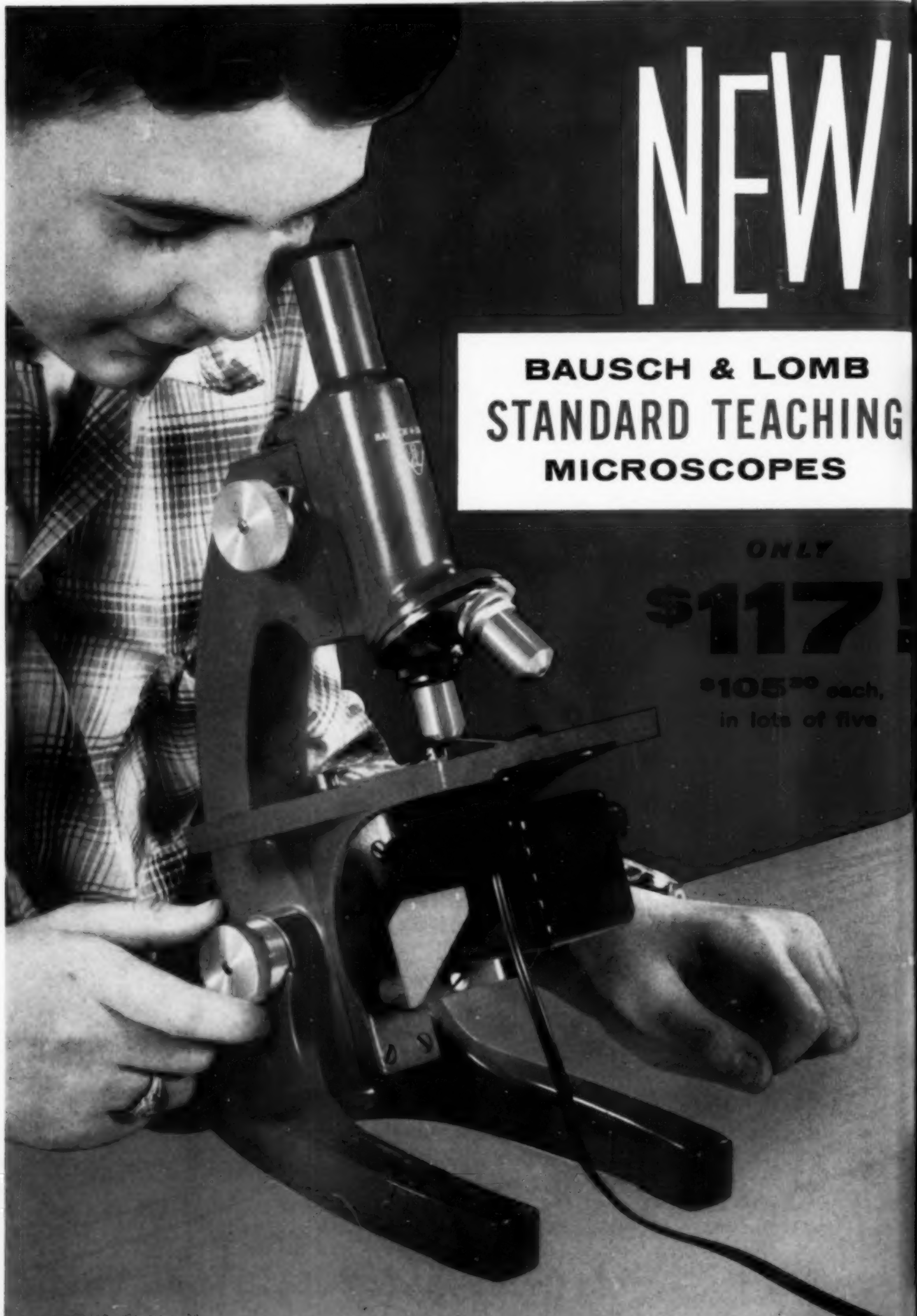
In another experiment, the energy released by fission of uranium-235 atoms under neutron bombardment is shown on an oscilloscope screen, where it can be compared with the much lesser energy released by the radioactive disintegration of the more common uranium-238 atoms.

Storage of chemical energy is illustrated by the green glow of highly reactive molecular fragments, known as free radicals, captured and kept at —450°, a temperature near absolute zero. This unique and visually spectacular experiment portrays vividly one of the most concentrated forms of chemical energy yet discovered by science.

Method of Distribution

This 33 minute, 16mm, color film is available for loan, or for sale, from the Office of Technical Information, National Bureau of Standards, Washington 25, D. C., or from the Bureau's Boulder Laboratories, Boulder, Colorado. The film has also been distributed among selected educational audio-visual centers serving school systems throughout the United States.

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Elementary School Science

(Continued from Page 2)

should be discussion during the experiment and after conclusions are reached. Experiments should be done many times by individuals or groups of children. Often an experiment that does not "work" is more successful in teaching the scientific attitude and scientific method. The reading of books and periodicals ranks high in the ways in which children learn science. Like any other method, it should not be used to the exclusion of all others. A science teacher has a responsibility to guide and help children with their reading. Here the skill is an important one, for vocabulary must be developed; a differentiation between fact and fancy must be made; and the encouragement to read science material for pure enjoyment, as well as to gain knowledge must be stressed. Children have to be helped to do their own thinking when they discover differences of statements in various books. They should be taught to challenge the authenticity and accuracy of conflicting or questionable statements by learning something about the author's background and by looking at the copyright date of the publication. There are many reasons for reading science materials in and out of the classroom. Children should be encouraged to go to books to check their own conclusions, to find information, to locate suggestions for help in conducting an experiment, and to answer or help solve a problem. They should be encouraged to use a variety of sources of reading material on any given topic. The more information obtained may make apparent varying points of view. Books are excellent guides and learning tools. The proper use of them is research on the elementary school level. Reports may be given to the class as a result of this research. These, of course, should not be read in an incoherent way, but rather presented in an informal and understanding fashion.

The alert science-conscious teacher will take advantage of community resources. These may include field trips to the local museum, planetarium, zoo, park, or a near-by farm; or they may include a walk around the school yard to identify trees or weeds, or a walk down the stairs to the basement to see the heating system of the school. Whether the trip be one which requires a special bus, or merely the stepping outside of the school building, the excursion should have a purpose. Children should know what they are to look for; attention should be directed to a few definite goals. On some occasions children may wish to collect specimens. A discussion of what may be brought back should be held before hand. When collected material will be of some use for further study, a few samples should be gathered for the entire group. Along with the collection of plants, the teacher should point up the need of conservation in gathering most natural specimens.

The use of audio-visual aids is essential in the effective teaching of science. Many excellent films, film strips, and slides are now available. In addition, the teacher should make wise use of programs scheduled for radio and television. As far as possible, the material presented should be familiar to the teacher, so that

children may with proper guidance use them intelligently. Pupil and teacher made materials can not be ignored in considering visual aids. Models, dioramas, murals, and the careful use of the chalkboard help children to reach better understandings.

During every phase of science teaching, the teacher should constantly be stressing the importance of scientific attitudes and methods. Children should be taught to be open-minded and not to jump to conclusions. While it is important to learn facts, teachers must never lose sight of the way in which they are learned and the way in which they are organized. Facts should be developed in a meaningful way, finally arriving at generalizations which will be useful in the daily living of the children. Teachers are inclined to give too many answers. Since it is important to help them find the answers, children should be encouraged to look at a matter from all sides; to turn to authorities for information; to evaluate the information and use it wisely; to be open-minded, tolerant of others' points of view; to think carefully before announcing a conclusion; and to be free of prejudice and superstition.

Science methods overlap each other. Lessons should be composed of many techniques. All lessons should begin with intelligent planning and be developed with the use of good judgment on the part of the teacher. When this is done in the elementary school, the result will be more children who have broader interests and knowledge of the world in which they live, as well as more students who will continue to study science in the high schools and colleges.

The spotlight is on science and science teaching today. It is up to each person interested in this important field to evaluate his work and to take advantage of the rich opportunities available to improve himself. Strong leadership in the elementary school science program is needed immediately. It is the responsibility of each educator to review the entire science program presented in the school system which concerns him and to understand the objectives and subject matter presented in the specific area in which he teaches. Now is the time to help develop the scientists of the future who will keep our nation in its rightful leadership in this complex technological age. ●

WHO ARE . . .

"THE SPIRITANS"

SEE PAGE FORTY

The Small Computer

(Continued from Page 8)

to make additions to the program or changes in the program almost immediately upon its completion. Debugging of new programs and revision of programs consume a great deal of machine time and when the machine involved is a giant computer, time can be very expensive. In working through parts of a problem to find the source of difficulty, the greater speed of a large computer is of no advantage. An inexpensive man tends to become the slave of an expensive machine.

Hence, some people have chosen to eliminate this expenditure of valuable machine time by placing new problems on a small computer for solution until the details are formalized and a satisfactory program is developed. Then if the volume warrants, the program is translated to the language of the large computer. In this type of operation the small problems and the "one-shot" problems never reach the large computer. This approach has another advantage besides the saving of money. It reduces the pressures which are exerted toward standardization of procedures. The engineer can feel free to try new approaches to his problem on the small computer while his old approach is being employed on the large computer.

Some large companies are taking still another approach to the application of small computers. Management has chosen to let each large department or division select a computer which will satisfy its own needs. The computing facility is on a completely decentralized basis. By having the computer close at hand, the engineer is encouraged to really make use of it rather than waste his time on a desk calculator or content himself with educated guesses or "ball park" answers. For this type of installation, care should be taken in selecting a computer which is relatively simple to program and operate so that the engineer can spend more time concentrating on finding methods leading to more accurate answers than on programming and operating the computer.

Another interesting application of a small-sized computer on a decentralized basis is its use as a special purpose computer. A major oil company is using an LGP-30 in one of its refineries. The computer has been set to assist in the one difficult task of finding a combination of operations that will produce the desired motor fuels on any particular day from the crude that

is presently available. In this application, the use of a central computing service is inadequate because immediate answers are important. Accurate solution of this problem can mean as much as $.01 per barrel difference in profit. Since over 100,000 barrels per day are involved in this operation, computation can make as much as $1,000 difference in profit per day.

The small company which cannot afford the price of a large computer or does not have enough work volume to warrant the use of a large computer, may find use for an installation similar to that in a department of a large company. Similar considerations should govern their choice of a computer. However, in addition to such things as ease of operation, they must also consider the capacity of the machine. In the small company when a problem is encountered which is difficult to squeeze into the small computer, there is no large computer standing by which may be used. Hence, it becomes even more important for the small company to select a computer which has a capacity adequate for the broadest range of problems they expect to encounter.

In summary, the speed and capacity of modern digital computers have greatly broadened the effectiveness of scientific and engineering efforts. The recognition of computer usefulness has been the impetus for the development of the giant brain. However, useful though it is, the giant brain is attended with difficulties. These difficulties can be overcome in many cases by the use of several small computers either to augment the large computer or, in some applications, to replace it. In addition, the small computer can be used in cases where computing volume and cost factors make the use of no other computer possible. We can expect that the recognition of its great potential will generate in the coming years a remarkable expansion in the use of the small computer. ●

★ ★ ★ ★ ★

Science In Kindergarten

(Continued from Page 15)

Except for the fastening of the wire to the cone there is nothing about the making of a pine cone bird feeder which is difficult even for the kindergartener. At no point can the individual effort result in failure.

No dangerous tools are used and about the only safety precaution is to form the loose end of the suspension wire into a loop so it does not endanger the eyes of the busy workers or their neighbors.

Suet does become greasy if the work lags, but if all material is kept on the outspread papers and stray bits are picked up from floors and the floor surface is wiped at once with paper towels there is little mess.

Fifty pounds of ground suet being manipulated by fifty pairs of hands will not cause nearly as much

temporary devastation as the same 50 pairs of hands at a finger painting session.

Pomander making with its pungent smells of apple sap, spices, and orris root seems to excite the interest of every small child. Some lose their enthusiasm and patience, but most youngsters learn a first lesson in perseverance as they stick hundreds of individual cloves into an apple to complete that present for mother. The pomander project is recommended for children having no place for using bird feeders.

My experience has indicated that very firm apples of the Delicious variety are preferable to oranges as pomander bases.

The teacher planning this project should scout a wholesale clove supply in advance. Cloves purchased in bulk cost only about 85 cents a pound. In small packages, as usually available in neighborhood stores, they may cost 20 times as much. If no wholesale condiment dealer can be found, meat dealers who cater to restaurants usually have cloves in bulk. They are used to stud baked hams.

Cinnamon also is cheaper by the pound. Orris root is sometimes carried by neighborhood druggists.

A flat cardboard box lid with several ounces of cloves and a firm apple are all each pomander maker needs to start his project. Some pupils prefer to stud the cloves on the surface of the apple in initials and patterns and then to gradually fill in all voids until the surface is completely firm and covered with cloves. Others meticulously start at one spot and gradually cover the whole apple. When an apple is completely impregnated with cloves it is carefully rolled in a mixture of cinnamon and orris root. It is then wrapped in aluminum foil and laid away for about ten days to ripen.

When dry and solid at the end of the ripening period each pomander is wrapped in a square of white net material, bunched at the top to provide a frilled top container or bag. A bow of ribbon is tied about the gathered top. A loop of ribbon to be used to hang the pomander in a clothes closet, the usual use to which it is put, is provided.

The source of the exotic aromatic products going into this project provides many study directions. Even small children understand and are interested in the story of how genteel people of long ago swung aromatic pomanders to and fro in front of them when they went near slaves who had not bathed recently.

These two simple bridges between a pupil's natural inquisitiveness and the world of knowledge into which the teacher is leading him are not important in themselves. The important aspect is to pick simple projects which for some reason can be used to associate something in a child's physical life and play with a new world of pictures and books. ●

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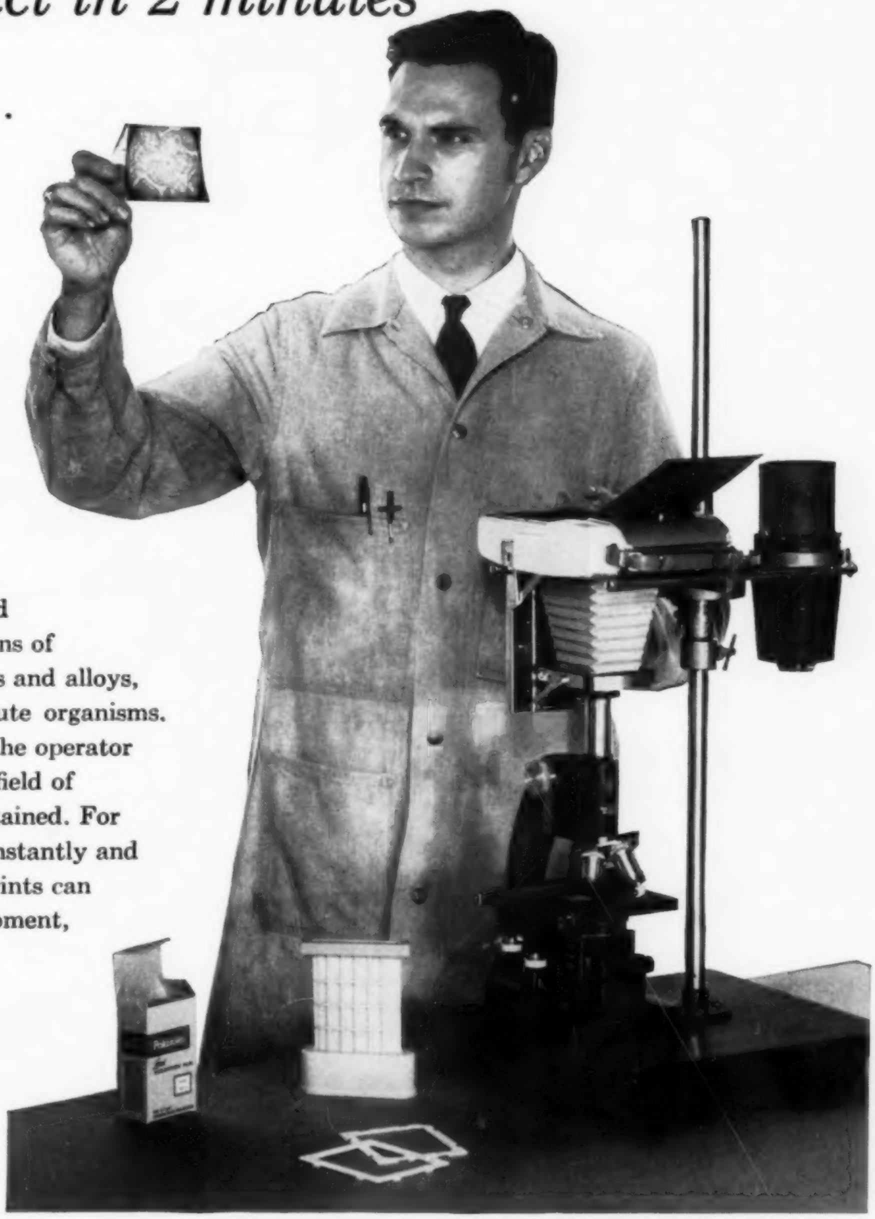

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After-School-Hours Training For High School Teachers

The National Science Foundation announced recently that it will accept proposals from universities and colleges interested in sponsoring In-Service Institutes for Secondary School Teachers of Science and Mathematics to be held during the academic year 1958-59.

A primary purpose of the In-Service Institute program is to assist colleges and universities in their efforts to encourage teachers in outlying school districts to take advantage of scientific training facilities not otherwise readily accessible to them. The Foundation has already announced support of 125 Summer and Academic-Year Institutes in colleges and universities throughout the Nation during the summer of 1958 and the following school year.

In-Service Institutes for secondary school teachers of science and mathematics will offer work in the subject matter of science and mathematics especially designed for these teachers. Institute meetings will be held outside regularly scheduled school hours — e.g., evenings, Saturdays, or late afternoons—so that teachers may attend while still teaching full time in their schools. A typical Institute might meet once a week for two hours for the full academic year of about 30 weeks. Half of these meetings might, for example, be devoted to laboratory work.

It is possible for a particular institution to offer courses in more than one subject-matter area in these in-service programs. Courses could be offered simultaneously, though not necessarily on the same evening, in mathematics, physics, chemistry, biology, etc., for instance. Any given participant should probably be limited to attending no more than two of these if he is to find time to do a good job on each. The In-Service Institute program contemplates that each group will be kept to less than thirty members so that discussion may be full and free.

Foundation support to some twenty-five In-Service Institutes will cover all tuition and fees, plus any other direct costs to the college or university directly attributable to the program. Though the Foundation does not provide stipend support for participants in the in-service program, the NSF grants provide funds to underwrite travel expenses in connection with attendance at the Institutes. Deadline for submission of completed proposals to the Foundation is March 15, 1958. Directions for preparing proposals may be obtained from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C. ●

Inorganic Bioelements

(Continued from Page 18)

	Human Body	Vegetation Dry Matter	Soil Dry Matter
Oxygen	66.00%	42.9 %	47.3 %
Carbon	17.5	44.3	.19
Hydrogen	10.2	6.1	.22
Nitrogen	2.4	1.62	----
Total Combustible	96.10%	94.92%	47.71%
Calcium	1.60	0.62	3.47
Phosphorus	0.90	0.56	0.12
Potassium	0.40	1.68	2.46
Sodium	0.30	0.43	----
Chlorine	0.30	0.22	0.06
Sulfur	0.20	0.37	0.12
Magnesium	0.05	0.38	2.24
Iron	0.004	0.04	4.50
Silicon	trace	0.00 to 3.00	27.74
Aluminum	trace	trace	?
Iodine	----	trace	----
Fluorine	trace	trace	0.10
Manganese	trace	trace	0.08

all other trace elements, if mentioned at all, are stated as traces.

All elements *listed are of course inorganic bioelements.*

The above figured as body compounds:

	Human Body	Vegetation Dry Matter	Soil Dry Matter
Water	65.00%	----	----
Protein	15.00%	10.00%	
Carbohydrates		82.00	
Salts	5.00	5.00	
Other	1.00	----	
Fat	14.00	3.00	

As will be seen from the above Oxygen, Carbon, Nitrogen all inorganic bioelements from air and water become, through metabolism, organic matter such as the carbohydrates, proteins that embrace in their substances the vitamins, enzymes, hormones and body tissues. Carbohydrates are no longer present as such in the human body, but are consumed as energy and become again Carbon Hydrogen and Oxygen. Nitrogen is either converted to proteins, or eliminated as urea or nitrates. That leaves approximately 5% as mineral matter which is recoverable as ash and thus subject to analysis. Of this amount 95% consists of the skeleton and teeth. Bones are constantly formed and resorbed. It is therefore possible to influence bone formation through dietary minerals, just as it is possible to influence the formation of body tissues, skin, and blood through dietary proteins, minerals and carbohydrates that in turn contain vitamins, hormones and enzymes. In this picture there is left out of consideration the catalysts and anti-metabolites mentioned earlier, of which ingestion corresponds to elimination, so that to that extent food composition is at variance with body composition. An attempt will therefore have to be made to analyze not only the composition of the 5% body salts or ash, but also of the total food ingested. The composition of the food of centenarians, would conceivably differ from the composition of the food consumed by a person who dies in middle age from heart disease or other degenerative disorders. Such are the

problems that face the student of health through dietary means. Nutritionists and dietitians are successful in their dietary recommendations only to the extent they manage to encounter foods of a nutrient balance needed by man already healthy. These may prove unavailing where gross deficiencies are already in evidence. They require first a reduction of what is excessively present, and then a correction with suitable dietary supplements in therapeutic doses. The disorders described earlier in this paper were all improved with inorganic food- and feed-supplements. Natural food products or "organic food" compounds would have proved entirely inadequate as far as the inorganic side of life is concerned. Fats and Protein deficiencies on the other hand are correctible with the requisite kinds of fatty acids in unsaturated condition, and the requisite amino acids that prove either absent or inadequately present. Furthermore the nutritional approach to health is a long range preventative method. Degenerative troubles and deficiencies came about gradually and take considerable time to correct. Where disease is present, diet alone is not likely to help anyone so that medical attention must not be neglected. There is also no substitute for surgery in critical cases, nor for mechanical treatments and massages where skeletal and muscular dislocations are involved. But of all these methods, nutrition is the subject that appears to be grossly ignored because not studied along the principles of biochemistry or biophysics. If none of the existing healing arts adopts the nutritional approach to health and disease, certain segments of the population may be expected to take matters into their own hands. This is already attempted by various "Health" advocates, but true economics will only come into effect when the principles of exact sciences are applied to the problems of metabolism, and nothing can be permanently corrected unless the causes are removed. ●

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New Books

The Teaching of Mathematics

• *By* THE INCORPORATED ASSOCIATION OF ASSISTANT MASTERS IN SECONDARY SCHOOLS, New York: Cambridge University Press, 1957. IX + 231 pp. $3.00.

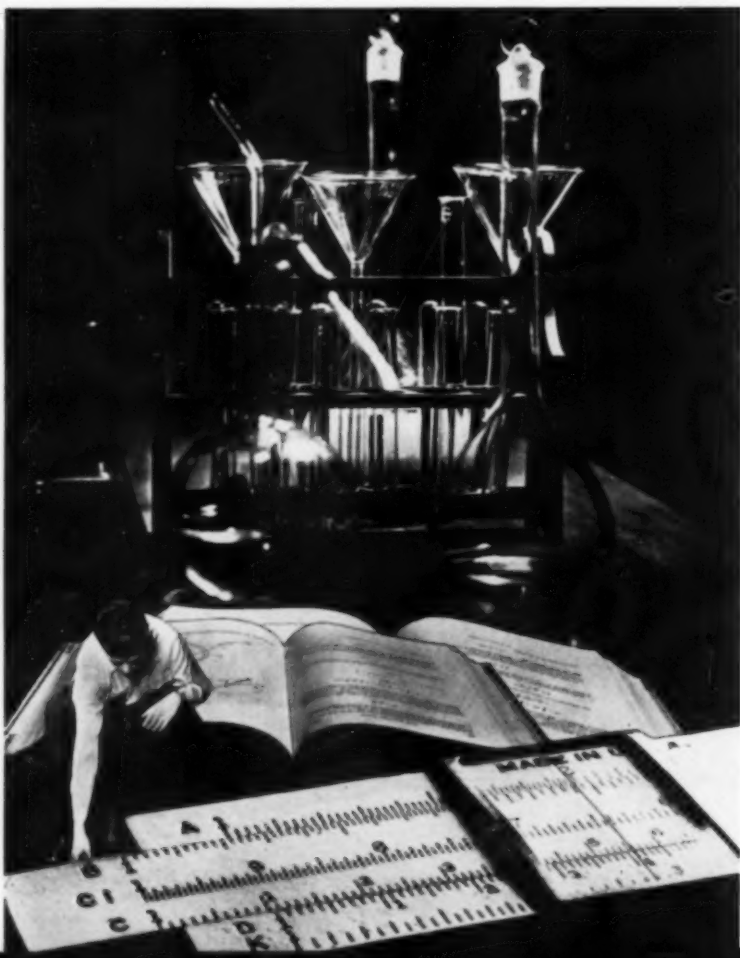
The timely appearance of this analysis of mathematics curricula and teaching methods should be noted by

1) all who are earnestly interested in communicating a genuine liking for the subject to their students;
2) those engaged in the preparation of eager young mathematics teachers.

Indeed, all who are in the least concerned about the scope of preuniversity mathematics training will find it profitable reading. This report, prepared by the group listed above, is the seventh in a postwar series dealing with the main subjects taught in British Secondary Schools.

The body of the report contains an extensive survey of syllabus material, including a discussion of the elements of arithmetic as presented in the nursery school and a summary of the arithmetical processes and concepts which should form part of the background of the student as he finishes primary school at the age of 11+. A syllabus for the third, fourth, and fifth year of the secondary school is outlined, with suggested correlation between topics of 1) arithmetic, 2) algebra, 3) geometry, 4) trigonometry, 5) graphical work. The various topics are discussed at length, with hints for stimulation of interest and effective presentation. There is also a section devoted to consideration of the teaching of the elements of calculus and mechanics in the fifth year.

Photo by Vic Kelley



Other topics covered are: the teaching of statistics, the mathematical library (with an excellent collection of titles), the teaching of the history of mathematics, the "mathematics room", the teacher's attitude.

Underlying each critical evaluation seems to be an endorsement of the psychologists' advice to concentrate on the needs of the *pupil;* order, selection, and treatment of topics must be "psychological rather than logical", and emphasis must be placed upon motivation and purpose rather than the traditional "Mathematics trains the mind." The belief that the benefit of mathematical training is automatically applied to nonallied fields is not sustained; instead, it is stressed that any such benefit depends upon *conscious* recognition and *conscious* transfer of logical thought processes to other material.

The increasingly important task of imparting and appreciation of at least some of the aspects of mathematical thought and processes to the nonmathematically-inclined is handled particularly well. The slow student as well as the brilliant one must be provided with stimulating material geared to his own level of interest and achievement: Reference to applications in surveying, meteorology, astronomy, and navigation is cited.

The book does not read like an idealistic education text. On the whole, it remains an objective review of present subject matter and teaching methods, and proceeds very logically to suggestions for revision. In many instances, appropriate problem types are illustrated. In an examination of the solution of geometry problems, it is refreshing to read that "mechanical copying-out is probably worthless".

The report is not as concise in spots as some might desire and is not recommended as a classroom text; however, it will provide very suitable collateral reading or reference material for classes in the teaching of mathematics.

Charles F. Sebesta, Ph.D.
Head: Department of Mathematics
Duquesne University

Reason and Chance in Scientific Discovery

• *By* R. TATON (Translated by A. J. Pomerans) Philosophical Library, Inc. New York. 1957. Pp. 171. $10.00.

This book concerns itself with the nature and origin of scientific discoveries. It is well written and definitely is a worth-while contribution to the philosophy of science. The author avoids excess theorizing and makes copious use of examples taken from the writings of famous scientists to illustrate his thesis. The selections from famous authors are well chosen and many are taken from authors whose works are not easily available to Americans.

The book is divided into two parts: In the first part the differences in and the basic methods used in the mathematical, theoretical, and the observational and experimental sciences are clearly pointed out. In part two, the factors in discovery are treated, and it is in this part that the title of the book is most fully justified. Part three concerns itself with various aspects of discoveries, such as originality, missed discoveries, and routine.

The printing is very good and there are many excellent illustrations. We recommend this book to all who are interested in the basic nature of science.

J. P. M.

The Spiritans

A History of the Congregation of the Holy Ghost.

• *By* HENRY J. KOREN, C.S.SP., S.T.D., Duquesne Studies, Pittsburgh, Penna. Publication date April 15, 1958. Pp. XXVII + 641. $6.50 (Paper $5.75).

As the history of the Spiritans (Holy Ghost Fathers) unfolds, we meet such diverse characters as their handsome young founder, Claude Francis Poullart des Places, who tore himself away from wealth and glamour, prestige and social acceptance, titles and a legal career, to get things going and then to die at the age of 30; James Bertout, who returned to Paris after the French Revolution, found the work of two generations in ruins and spent himself in singlehandedly rebuilding it, only to see a life-time of effort, destroyed by a vicious government coup when he reached the age of eighty; Francis Libermann, a Rabbi's son, who did through brilliant diplomacy and amazing holiness what Bertout had failed to achieve, even though epilepsy dogged his early years and tragedy clouded the evening of his life; James Laval, a physician turned priest, at whose grave in Mauritius 50,000 Christians and Mohammedans still gather in homage on the anniversary of his death; Stanislas Arragon, whose wild vigor made even his cassock "look quite venerable after two days' wear"; Prosper Augouard, the "Cannibal Bishop," and Peter Gourtay, the "Gangster Bishop," whose territories held mysteries enough to make even a strong man quail. These and scores of others pass in review down the two and one-half centuries during which the little band of founding seminarians has grown into a worldwide organization that counts over seven thousand members and aspirants.

This book is no mere work of journalistic propaganda. It rests four-square on a mountain of documentary evidence which long and patient research has charted in scrupulous detail, letting the chips fall where they may. Yet even through the primness of scholarly format and the staidness of careful objectivity, one cannot help hearing the strains of "*Semper Paratus*" or an echo of the Marines' *Hymn*. God's own Corps is marching on and all who love a parade will thrill to the rhythm of its step.

The Church and Modern Science

• *By* PATRICK J. MCLAUGHLIN, B.D., D.SC. Philosophical Library, Inc. New York. 1957. Pp. 374. $7.50.

The Catholic scientist and the philosopher will find in this book a convenient one volume source of the pronouncements of Pope Pius XII on science.

The book is divided into two parts. Part one is philosophical and it discusses the traditional and modern views of science. Part two is made up mainly of the discourses and writings of Pius XII on science. The style is simple and clear. The author has logically arranged his own discussions and the translation of the papal documents is good. To help the reader subtitles have been inserted in the translations and the documents are not presented in chronological order but grouped into classifications according to subject-matter. Three appendices have been added, one on the church's attitude towards miracles, the second is a listing of the sources of the acts of Pius XII and the third is a fairly complete bibliography of the philosophy of science.

The sources of the acts are mainly from English periodicals but very few of them are easy for the average American teacher to obtain. The only American sources cited are the *Catholic Mind* and Yzerman's *The Unwearied Advocate*. Unfortunately he overlooks the best and most recent American source, *The Pope Speaks* (3622 12th St. N. E., Washington, D. C.).

This book should be in the library of every college and Catholic seminary. It is not another book on the religion and science controversy but an authoritative source of information.

J. P. M.

Morphology of Plants

• *By* HAROLD C. BOLD, PH.D. New York. Harper and Brothers, Publishers. 1957. Pp. XXIII + 652. $8.00.

This comprehensive textbook is designed to present a discussion of the morphology and reproduction of the more important "types" of plants in the plant kingdom. The "types" are selected by application of two criteria: 1) their ready availability, so that students can observe the living plants; 2) their suitability as an introduction to more specialized treatments which students would meet in advanced classes.

The content of the book is organized into a preface, thirty-one chapters, an appendix and an index. The first of the thirty-one chapters is an introduction, the next twenty-eight chapters deal with the present day plants from the twenty-four divisions which the author recognizes, the thirtieth chapter deals with plants of the past and the last chapter is a general summary. The appendix is a collection of methods of assembling and preparing living materials for student use.

Discussion questions at the end of each chapter aid the student in summarizing the essential data of the chapter. The diagrams and photographs, which are liberally distributed throughout the text, are of excellent quality and aid the student in making his own observations, but do not substitute for them.

The approach of the author and his choice of words is very appealing to this reviewer and is especially pleasing in the preface to the student, in the introduction and in the general summary.

It would seem to this reviewer that all teachers of botany or biology and all students of botany who go beyond the first semester of college botany should be familiar with this book. Many amateur botanists who have not had the opportunity of taking a college course will find this book both interesting and helpful.

Helena A. Miller, Ph.D.
Biology Department
Duquesne University

How To Do An Experiment

• *By* PHILIP GOLDSTEIN. Harcourt, Brace and Company. New York and Chicago. 1957. Pp. 192. $2.60.

Junior and senior high school science students are very often too dependent on text books for their understanding of science. This little book will help the better student to start making independent investigations. Philip Goldstein conclusively demonstrates that at the junior high school level students can start significant research in chemistry, biology and physics.

The first chapter discusses the methods of science in general, methods of collecting data, forming hypotheses, the nature of theory and law. The remaining chapters are an expansion of the material in the first chapter. The chapters are short and each clearly and comprehensively covers its topic. Many pertinent examples of the use of scientific procedures are given, some are taken from the history of great discoveries in many sciences. The author also gives examples of student experiments and criticizes their strong and weak points.

The style is pleasing and the author frequently introduces a little quiet humor, as for example, his use of John Godfrey Saxe's poem, "The Blind Men and the Elephant" in warning the reader of the danger of incompleteness in observation. The printing and binding are excellent and the book is pleasantly illustrated.

We strongly recommend this book to students who are interested in independent study, or who are seeking ideas for a science fair project.

J. P. M.

Scientific American Books

Simon and Schuster. 1957. New York. $1.45 each (paper).

PLANT LIFE, Pp. XIII + 237
NEW CHEMISTRY, Pp. XI + 206
LIVES IN SCIENCE, Pp. XIV + 274

The *Scientific American Books* are essentially reprints of the fine articles which have appeared in the pages of this excellent review. Even those with a full file of the *Scientific American* will find these books an excellent addition to their library. Each book contains a selection of articles on a selected topic. The articles are arranged in a logical sequence, resulting in a highly informative and readable book.

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We recommend these books for your science-reading shelf, and because of their low price we suggest that you encourage your students to purchase personal copies.

J. P. M.

New Frontiers of Knowledge

• *Edited by* M. B. SCHNAPPER. Public Affairs Press. Washington, D. C. 1957. Pp. x + 125. $2.75.

This book is a symposium by distinguished writers, notable scholars, and public figures. It is based upon a series of talks broadcast throughout the world by the United States Information Agency. Thirty-six authors contribute and they are all outstanding in some field of science, social science, government, international problems, and journalism. Americans, Europeans, Asians, and Africans contribute. While there is no direct unity in their articles, the editor has arranged them in such order that the reader easily passes from one to the next.

We recommend this work on the basis of its content and also as a source of information on the type of broadcasts that are being transmitted by the Voice of America.

J. P. M.

Microwave Propagation

(Continued from Page 13)

propagation retarded progress against the line-of-sight shibboleth. It appears essential for theory and experiment to cross-fertilize each other continually.

Lastly, this quarter century of gradual progress in understanding the limitations of the line-of-sight shibboleth about microwaves may serve as an antidote to the excessive condensation to which scientific history is frequently subjected in textbooks. The laws of nature are presented as accepted revealed truth, frequently without accompaniment of insight into the devious and very human struggle even of the most successful scientists before their discoveries come to be accepted even by contemporary experts in the same specialty. We should all make an effort to understand why it took so long for expert opinion to come to believe in a discovery initiated by Marconi in 1932-1933. It was held by the late American inventor Armstrong that the best criterion for invention is this: find out what the experts said or wrote when they first heard about it, because while an invention must be in accord with the immutable laws of nature in order to be successful, it cannot be obvious at first to contemporary experts or it would have been invented earlier[37]. I close with the final sentences of Armstrong's 1951 tribute to Marconi's early discoveries about transatlantic wireless and the short wave revolution, before the significance of the final microwave work was recognized[38].

"The key to his achievement is that he was able to appreciate the limits of his own knowledge, and to doubt what others were ready to accept as dogma. For that rare ability and his infinite perseverance he gained the reward that always awaits the true discoverer—he builded better than he knew." ●

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★ ★ ★ ★ ★

Pasteur Shows Importance Of Basic Research

"Science in its highest form never advances without its results benefiting industry sooner or later."

So wrote one of the greatest basic researchers of all time—Louis Pasteur. It is all the more remarkable because this French scientist died before the turn of the 20th century.

Just 100 years ago, Pasteur discovered that the fermentation of lactic acid is caused by living microorganisms. The discovery, like so many others arising from basic research, was ahead of its time. The science and technology of his time were too young to make any but limited use of this basic knowledge. Yet one of the turning points in human history was to rise from this new knowledge. Having made the discovery, Pasteur went on to develop further his monumental germ theory of disease, the basis of much of modern medicine.

So from one discovery, evolved two, and the chain reaction of basic research was at work. President Eisenhower has stressed the need of increasing this type of research. In his first "chins-up" speech on national security, he said in part, ". . . a . . . critical need is that of giving higher priority, both public and private, to basic research."

The chemical industry has long recognized this need. This year it will spend around $53 million on basic research alone. And this does not include the millions given by chemical companies to universities, colleges and private institutions for carrying on this type of research.

In a sense basic research is a thing apart. The researcher is guided basically by his desire to fully understand the workings of nature. An incidental aspect of this is that basic research is a source of all technological progress.

Pasteur never forgot the practical applications of science, though he dealt in the theoretical. "There is science and the applications of science, and both are linked together as the fruit to the tree," he wrote.

Indeed it is easy to see for Pasteur's work is one of the best examples. Without highly controlled fermentation and bio-synthesis techniques, antibiotics would be a laboratory curiosity today. Citric acid, vitamins, hormones, steroids and a host of chemical intermediates would be rare and costly. Methods for producing such chemical building blocks on an economical basis simply would not exist. And now leading scientists have predicted that new chemicals, drugs and nutrients produced by microscopic molds and germs may play increasingly important roles in human life in the near future. Many new products of fermentation are on the horizon. Included are food for animals and human beings. Many high-protein microorganisms, such as yeasts, may provide part of the answer to food production problems caused by the world's growing population. Among the specific nutrients that may be provided by fermentation are some amino acids, the building blocks of proteins. Such an acid, lysine, which is essential to building body tissue, has recently been produced by fermentation. It is also being synthesized by chemical means.

Thus, many of today's practical benefits trace their origins to a basic discovery made 100 years ago. They are linked as the fruit to the tree.

—Chemical News.

★ ★ ★ ★ ★

Molybdenum

(Continued from Page 6)

strength. Chief markets for this pigment are paints, printing inks and plastics. Because of its high visibility and intensity it has replaced chrome orange as the pigment specified for international orange (the color which adorns airport towers throughout the world). It also is included in the specification for aircraft gloss enamel.

Lakers or toners for colors also incorporate versatile molybdenum. These pigments consist of basic organic dyes precipitated by phosphomolybdic acid (PMA), phosphotungstic acid (PTA) or mixtures of both (PMTA). They are used mainly in printing inks and interior paints and enamels. The PMA lakes have greater tinting strength and are much cheaper but on exposure to light tend to darken. The PTA colors are more brilliant but are subject to fading. Thus mixtures of the two acids are often preferred.

Other Chemical Uses

Although molybdenum alloy steels and irons are made from technical grade oxide, briquets or ferromolybdenum, pure moly chemicals are used in the production of metallic molybdenum. Moly chemicals also have found use in metal surface treatment, ceramics, one coat enamels (to promote adhesion, and enamels opacified with titania (as a tint).

There are other uses for moly chemicals and new ones on the horizon—but suffice it to say that between both its metallurgical and chemical sides, molybdenum is truly one of nature's most versatile elements. ●

New Tests Featured by ACS Examinations Committee

The examinations committee of the Division of Chemical Education ACS has launched the 1958 Testing Program.

A new test has been prepared by the General Chemistry sub-committee under the chairmanship of Dr. Donald D. Wright of Brooklyn College. As an experiment the test has been released simultaneously in two forms, 1958 and 1958S. Both forms contain identical items, but in different order. This will help minimize copying, when used in the same examination room under crowded conditions, or in different sections during the day.

The Organic Chemistry sub-committee, under the chairmanship of Dr. Bernard A. Nelson of Wheaton College has prepared a new test, Organic Chemistry, Form 1958. The test is for a full year course, but a part may be given at the end of the first semester, or the entire test at the end of the year.

The High School Chemistry Test, Form N, has gone through a second printing. The test was prepared under the chairmanship of Mr. Elbert C. Weaver of Phillips (Andover) Academy and a sub-committee of 42 teachers appointed jointly by the Examinations Committee and the National Science Teachers Association.

The Spring 1958 program features tests in all fields of undergraduate chemistry: General Chemistry, Qualitative Analysis, Quantitative Analysis, Organic Chemistry, Physical Chemistry and Biochemistry. Several forms are available for each field, and national norms have been calculated in all but the new tests.

Further information and copies of all the tests may be obtained from Theodore A. Ashford, Committee Chairman, St. Louis University, St. Louis 4, Missouri. These tests are available to members of the faculty of higher educational institutions. Please use official stationery and use the official channels of the college when making inquiries. Limited copies of older examinations are available in addition to the tests featured in the testing program.

★ ★ ★ ★ ★

NSF Plans Conference

Plans for a conference on "Research and Development and Its Impact on the Economy," to be held in Washington in the spring, were announced recently by Alan T. Waterman, Director of the National Science Foundation.

The conference is being planned by the Foundation as part of its program to study the volume of research and development in all sectors of the economy, in terms of both expenditures and manpower engaged in the work, and of the impact of this important activity on the Nation's economic well-being.

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NO FRAGILE PARTS — Durability was a prime consideration in the design of the GENATRON which, with the exception of insulating members, is constructed entirely of metal.

The only part subject to deterioration is the charge-carrying belt, which is readily replaceable.

NO TRANSFER BODIES — In all conventional influence machines, whether of Holtz or Wimshurst type, electrical charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies have always taken the form of metal brushes, rods, button disk or segments — each of which, inevitably, permits leakage of the very charge it is intended to carry, and thereby sharply limits the maximum output voltage.

It is a distinguishing difference of the GENATRON that electrical charges, conveyed by a non-metallic material, are established **directly upon the discharge terminal.** The attainable voltage accordingly depends only upon the geometry of that terminal and the dielectric strength of the medium by which it is surrounded.

Unique Features of the CamboscO Genatron

DISCHARGE TERMINAL Charges accumulate on, and discharge takes place from, the outer service of a polished metal "sphere"—or, more accurately, an oblate spheroid.

The upper hemisphere is flattened at the pole to afford a horizontal support for such static accessories as must be insulated from ground. A built-in jack, at the center of that horizontal area, accepts a standard banana plug. Connections may thus be made to accessories located at a distance from the GENATRON.

CHARGE-CARRYING BELT To the terminal, charges are conveyed by an endless band of pure, live latex — a CamboscO development which has none of the shortcomings inherent in a belt with an overlap joint.

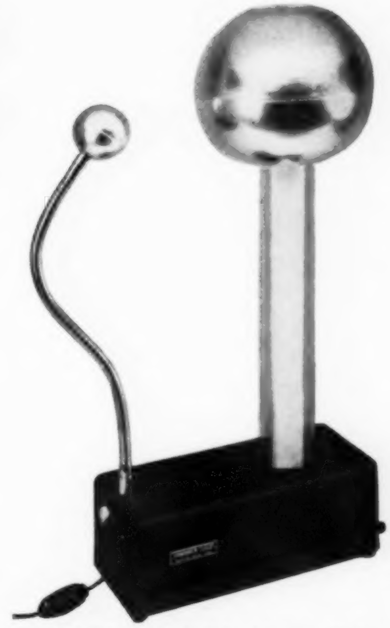
DISCHARGE BALL High voltage demonstrations often require a "spark gap" whose width can be varied without immobilizing either of the operator's hands.

That problem is ingeniously solved in the GENATRON, by mounting the discharge ball on a flexible shaft, which maintains any shape into which it is bent. Thus the discharge ball may be positioned at any desired distance (over a sixteen-inch range) from the discharge terminal.

BASE ... AND DRIVING MECHANISM Stability is assured by the massive, cast metal base—where deep sockets are provided for the flexible shaft which carries the discharge ball, and for the lucite cylinder which supports, and insulates, the discharge terminal.

The flat, top surface of the base, (electrically speaking), represents the ground plane. Actual connection to ground is made through a conveniently located Jack-in-Head Binding Post. The base of the Genatron encloses, and electrically shields, the entire driving mechanism.

PRINCIPAL DIMENSIONS The overall height of the GENATRON is 31 in. Diameters of Discharge Ball and Terminal are, respectively, 3 in. and 10 in. The base measures 5¼ x 7 x 14 in.



GENATRON, With Motor Drive

Operates on 110-volt A.C. or 110-volt D.C. Includes: Discharge Terminal, Lucite Insulating Cylinder, Latex Charge-Carrying Belt, Discharge Ball with Flexible Shaft, Accessory and Ground Jacks, Cast Metal Base with built-in Motor Drive, Connecting Cord, Plug, Switch, and Operating Instructions.

No. 61-705 - - - - $98.75

GENATRON, With Speed Control

Includes (in addition to equipment itemized above under No. 61-705) a built-in Rheostat, to facilitate demonstrations requiring less than the maximum output.

No. 61-708 - - - - $109.00

No. 61-710 Endless Belt. Of pure latex. For replacement in No. 61-705 or No. 61-708 **$3.00**

CAMBOSCO SCIENTIFIC COMPANY

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BOSTON, MASS., U. S. A.